Science and Mathematics Education Centre

Enhancing Students' Learning Experiences Outside School (LEOS) Using Digital Technologies

Sandhya Devi Coll

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Human Ethics (For projects involving human participants/tissue, etc.) The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number # SMEC-53-12

Signature:

Date: 28/08/2015

Dedication

This thesis is dedicated with much love to my mother, Sumintra Appana, my beloved husband, Richard Kevin Coll and the memory of my father, the late Balram Appana and not forgetting my treasured feline friend, Coco Channel.

Abstract

This thesis reports on an inquiry on enhancing students' learning experiences outside school (LEOS) using digital technologies. The inquiry took the nature of an ethnographic case study which was conducted over a year. The case study involved a private religious school in rural New Zealand, where Year 10 (14 year old) students visited informal science institutions (ISIs) at the end of each school year. The sample comprised 65 students and 10 teachers. Two research questions guided this inquiry. The first research question sought to understand current practices involved in preparing and assessing students' learning experiences at an ISI, in this case a predator-free native forest. Student, teacher, and ISI staff perceptions of these experiences were explored using semi-structured interviews, before, during, and after the visit. These data were triangulated using photographs, field-notes, unobtrusive classroom observations, student work-books, and teacher planning diaries. The findings from this first part of the study revealed that very little preparation was done for each LEOS and that the site visit was scheduled on the second last day of the school year. Additionally, the teachers who taught these topics were not necessarily involved in planning the visit and most did not accompany the students to the ISI. It appeared then that LEOS was seen as a reward instead of an informal learning experience where students could construct knowledge through social interactions. These findings then led to the second research question which explored an integrated learning model to enhance science learning when students and teachers engaged in LEOS.

The second research question examined whether or not an intervention based on learning support provided by digital means had any effect on the desired learning outcomes when evaluated against the New Zealand Curriculum achievement standards. The same cohort of students now in Year 11 (15 years old) and their teachers were involved in the intervention part of the inquiry. This stage of the inquiry comprised a three phase intervention. The first phase of the intervention placed emphasis on improved pre- and post-visit planning for a Physics achievement standard titled *AS90943, The Design Game-Keeping Your Home Warm*. The ISI visited was the *Show Home* which provided the context for informal learning on

building design and heat insulation. Students, teachers, and the ISI staffs' perceptions of these experiences were explored using semi-structured interviews, before, during and after the visit. These data were triangulated using photographs, field-notes, making unobtrusive classroom observations, analysing student work-books, assessment results, and teachers' planning diaries. The findings revealed a substantial improvement in both students' engagement with the topic, their engagement with the ISI staff, and better performance in their summative assessment. While the teachers spent time to improve pre- and post-visit planning, this phase did not see the use of any social software technologies, even though the students were keen to share their findings with each other, digitally.

The second phase of the intervention employed one tool of the learning management system, Moodle namely, *forum*. The achievement standard explored was Biology, AS90926, *Report on Biological Issues*. The ISIs visited were a pine forest (*Rakau Paina* Stand) beside the school, which involved experts on pest control from the Regional Council, and an *Island Ecological Reserve*, a predator-free forest (the same sight used for the first part of the study to address research question one). The concepts covered were biosecurity and biodiversity. The School Career Advisor accompanied the students who looked for volunteer job opportunities during school holidays. The teaching and learning utilised a blended learning environment where students and teachers collaborated using *forum*. Once again students, teachers, and the ISI staffs' perceptions of these experiences were explored using semi-structured interviews before, during and after the visit. Data triangulation involved photographs, field-notes, unobtrusive classroom observations, student work-books, *forum* postings, assessment results, and teachers' planning diaries. The summative assessment results revealed a slight improvement in student performance compared to the previous year. While students collaborated using *forum*, this phase did not see the use of *wiki*, which led to the third phase of the intervention.

The third phase of the intervention integrated the second tool of Moodle called *wiki*. The achievement standard explored was on Space Science, AS90954, *Lunar-Our Moon*. The ISI visited was an *Observatory*. Student attainment on this standard showed a poor pass rate in previous years, attributed by the teachers to the lack of teaching resources. For this phase of the study, the concepts on astronomical cycles

affecting Earth were delivered using a blended learning approach. Data triangulation involved photographs, field-notes, and unobtrusive classroom observations, student work-books, *wiki* postings, assessment results, and teachers' planning diaries. This phase saw improvement in pre- and post-visit planning, and co-construction of knowledge using *wiki*, which resulted in a substantial improvement in student attainment for this achievement standard.
The findings from this inquiry suggest that science students can benefit from the use of an integrated learning model when engaging in LEOS. The New Zealand curriculum emphasizes contextualizing science learning, which it seems can be achieved by sound pre- and post-visit planning, and helping students collaborate and co-construct knowledge using digital technologies within learning management systems such as *forum* and *wiki* on Moodle.

The findings of the third phase of this inquiry also have implications for including informal science education settings (ISIs) in the learning of science and potentially in science teacher preparation resulting in the development of positive attitudes (e.g., value, interest, excitement for science), an open mind for change, and confidence in teaching. It is also thought to help in the development of preservice teachers' science skills as they themselves experience teaching in diverse contexts relating to the diverse needs of students. Another benefit for preservice teachers would be autonomy in learning because using ISIs to engage students with science learning provides for a deeper understanding of learning, along with diversifying their teaching strategies.

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(Source: https: //www.google.co.nz/?gws_rd=ssl#q=image+of+iceberg)

Informal learning, base of the iceberg, the larger but hidden part of learning, is universal (everyone learns informally during life's experience), ubiquitous, and continuous (not limited to specific locations and times). But, it is largely unconscious learning, resulting in tacit funds of knowledge and banks of skills that are used every day to negotiate our way through life. In particular, unconscious learning creates the basic assumptions, which all students bring to any new learning. It could be said that informal learning impacts on formal and non-formal learning. The values, beliefs, sense of confidence, expectations, the prior knowledge, skills and attitudes, which students bring unconsciously, will determine the responses of the students to the new learning. Planned learning can build on informal learning, redress some of the undesirable outcomes of informal learning; and teachers can help the students to become more conscious of their prior learning through dialogue between formal, non-formal learning and informal learning. (Rogers, 2014, ¶1)

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CHAPTER ONE
INTRODUCTION

Overview of the Chapter

This chapter provides an introduction to the thesis. It begins with the background and justification for this inquiry into student learning experiences outside school (LEOS) followed by the nature, scope, and purpose of the inquiry. The assumptions and terms used in the thesis are then detailed, along with a discussion of the significance of the inquiry. The chapter concludes with a description of the context of the study, and an outline of the organisation of the thesis. Section 1.1, which follows, describes the background and justification for the inquiry.

1.1 Background and Justification for the Inquiry

This inquiry consists of an investigation into ways of enhancing student learning experiences outside school (LEOS). In selecting this area of research, I have been influenced by my secondary school teaching and learning experiences in both New Zealand and Fiji. Being an effective science teacher entails much more than just changing one or two variables of my teaching and maintaining high expectations from my students. Instead, I realised that there is a need to enact a successful chain of interactions, not just for one person, or even one person at a time, but for a social network, producing and sustaining learning environments that build upon 'fluent transactions' that facilitate collective and individual outcomes. Teaching science is a collective endeavour, and it is important that all participants, teachers, and students enact practices intended not only to promote their achievement, but to expand the agency of learning for others. As a result of these experiences, I came to the conclusion that the learning of science should not be confined to the walls of the classroom.

Students need to visit sites outside school where science could be seen and experienced. However, the literature indicates that most teachers fail to provide proper preparation of their students, and poorly plan the learning activities during

LEOS. Research suggests that teachers often just use worksheets to keep students busy recording what they observed and this does not take advantage of such learning opportunities during fieldtrips (Griffin, 1994, 2004; Griffin & Symington, 1997; Jarvis & Pell, 2005). Learning during out-of-school visits could also be limited as a result of missed opportunities if the objectives are ill-defined and if the visit lacks preparedness, and uses poor pedagogy (Rennie, 2007). Further support for the above view comes from reports in the science education literature, which suggest that outdoor learning is strongly connected to pedagogies that promote active learning, self-control, real-world experiences, group work and inquiry learning (Ash & Wells, 2006; Csikszentmihalyi, 1999; Dori & Tal, 2000).

A number of authors have highlighted the importance of informal learning in out-of-school settings such as science centres, botanic gardens, museums, and zoos, or industrial sites, collectively known as *informal science institutions* - ISIs (Allen, 2002; Brown, Collins & Duguid, 1989; Falk & Dierking, 2000; Griffin, 2007; Leinhardt & Knutson, 2004; Rennie & Johnston, 2007; Tofield, Coll, Vyle, & Bolstad, 2003; Tal, 2012). However, the lack of awareness on the importance of informal learning and its contribution towards understanding of scientific concepts taught in classrooms, may never lead to it gaining much recognition. The fact that LEOS is part of the school calendar in most if not all NZ schools, and that each year Board of Trustees (BoT) provide resources, manpower and finance to support out-of-school learning experiences, suggest that LEOS is an integral part of science learning. The literature suggests that collaborative social interactions promote learning and social construction of knowledge, especially during LEOS (Brown, Collins & Duguid, 1989), but teachers seldom include students in planning for LEOS programs. As a consequence, there are seldom curriculum-related objectives, meaning students tend to wander around the ISIs with no clear purpose, and are not able to appreciate the importance of informal learning, and how it influences their understanding of science. Section 1.2, which follows, explains the nature and scope of the inquiry.

1.2 Nature and Scope of the Inquiry

This inquiry comprised of an in-depth investigation into enhancing students' learning experiences outside school (LEOS) using digital technologies. The inquiry, considered an investigation involving Year 11 students at a rural private religious school who participated in out-of-school visits. This school was chosen because the staff and students were willing to participate, thus it was chosen for reasons of convenience. This inquiry took the nature of an ethnographic case study (Lincoln & Denzin, 1994; Lincoln & Guba, 1985; Merriam, 1988), and the investigation seeks to establish ways of enhancing students' learning experiences outside school. Case study research is a holistic approach which uses multiple sources of evidence to analyse or evaluate a specific instance, in this case a blended learning environment (Anderson & Arsenault, 1998). The research paradigm in this study was *constructivist-interpretive* which employed qualitative methods such as semi-structured interviews, and the data was triangulated using photographs, field notes, and unobtrusive classroom observations, student work books, student assessment results, teacher planning diaries, and postings on *forum* and *wiki*. Case study research is process oriented, flexible, and adaptable to changes in dynamic circumstances (Anderson & Arsenault, 1998). Section 1.3, which follows, describes the purpose of the inquiry.

1.3 Purpose of the Inquiry

The purpose of this inquiry was to gain a better understanding of how LEOS might improve the learning of science. There were two research goals that informed this inquiry; to better understand teachers' current practices in LEOS are effective in producing the desired learning outcomes for developing scientific understanding as evaluated against the New Zealand Curriculum achievement objectives; and to develop and evaluate an intervention to improve the learning of science using LEOS. These goals were formulated into two research questions.

Research Question One

Are New Zealand teachers' current practices in LEOS effective in producing the desired learning outcomes for developing scientific understanding as evaluated against the New Zealand Curriculum achievement objectives?

Research Question Two

Is an intervention based on learning support provided by digital means effective in producing desired learning outcomes when evaluated against the New Zealand Curriculum achievement objectives?

Section 1.4, which follows, describes the assumptions and definitions of the terms used.

1.4 Assumptions and Definitions of Terms

The following assumptions are central to this inquiry:

1. Individuals construct knowledge during out-of-school visits by participating in activities where they interact with others and with artifacts (e.g., interactive exhibits, signage, etc.);
2. The construction of knowledge is influenced by the learner's context, prior knowledge and social interactions with teachers, ISI staff and other students;
3. Digital space allows students significant autonomy and this encourages active participation in learning; and
4. LEOS helps in conceptual learning, enrichment, social and emotional engagement, improving attitude to science, and reinforcement of certain content.

Learning Experiences Outside School (LEOS): refers to visits to a variety of out-of-school environments such as natural history museums, zoos, science centres, planetariums, and visits to manufacturing industries.

Social Constructivism: emphasizes the collaborative nature of learning where students learn through social interactions, either face-to-face or virtually.

Field-based experiences: refers to different types of engagement the students make during LEOS including engagement with artifacts, ISI staff, other students, teachers, community helpers and parents.

ISI Staff: refers to education officers at different ISIs.

Moodle: an acronym for *Modular Object Oriented Dynamic Learning Environment* an open-source e-learning software platform. Section 1.5, which follows, outlines the significance of the inquiry.

1.5 Significance of the Inquiry

The findings from this inquiry would describe a blended learning environment approach used to help enhance students learning experiences during LEOS, where students will be taught to use Moodle when preparing for field trips and also for discussions after the trip. Additionally, it is expected that increased motivation and encouragement will lead to collaborative social interactions, which may promote learning and the social construction of knowledge (Brown et al., 1989; Lewin, 2004).

The inquiry would also provide recommendations for professional development for teachers in schools, both locally and internationally. Furthermore, it is hoped that this work would help inform science educators across educational levels in New Zealand and overseas about the preparation involved in taking students outside school, and help in the design of curriculum and teaching approaches to better prepare students for LEOS. ISI could be used as an informal science setting in pre-service and in-service teacher education programmes. Additionally, there could be an expansion in research on LEOS which focuses on the teacher's role in preparing for field trips. This could potentially be useful in overcoming lack of motivation and understanding of abstract science ideas. Section 1.6, which follows, describes the context of the inquiry.

1.6 Context of the Inquiry

The New Zealand Science Curriculum is based on a learner-centered, constructivist based view of learning, where teachers are expected to provide opportunities for a variety of learning experiences in science, including LEOS, to enrich student experiences, motivate them to learn science, encourage life-long learning and provide exposure to future careers (Hofstein & Rosenfeld, 1996). LEOS forms an important part of extending science learning experiences in many schools in New Zealand. However, to make the most of LEOS, it is important that adequate preparation is done, before, during and after visiting any ISI.

The last two decades of research in this area suggests that LEOS and field trips have not necessarily been that effective as a means to improve school-based learning (Rennie & McClafferty, 1996). The use of LEOS according to St John and Perry (1993) serves to bridge the 'critical disjunction' which exists between science and popular culture. Tofield et al. (2003) stress that there is often lack of teacher preparation, and Tal and Steiner (2006) assert that teachers mainly play a passive role during LEOS, such as managing student behaviour rather than actively mediating, encouraging and questioning students' findings. School visits are mainly controlled by the teacher to meet certain learning outcomes; however, some degree of choice is appreciated by both teachers and students (Bamberger & Tal, 2007; Falk & Dierking, 2002; Rennie & McClafferty, 1995, 1996). Jarvis and Pell (2005) stress the importance of teacher preparation and coordination, which they say strongly, influences students' engagement and enthusiasm for science. Anderson, Lucas, Ginns and Dierking, (2000) and Bolstad, (2001) report that in order to enhance better learning outcomes from out-of-school activities, teachers should plan accordingly, linking out-of-school visits to *specific* curriculum objectives, and linking these objectives *directly* to activities during the visit. This stress on the importance of well-structured LEOS is supported by Orion and Hofstein (1994), who say strong links provide meaning to abstract science ideas studied in the class. Hence, there is a need to integrate visits with teaching programmes and use out-of-school activities to complement, not replace, learning activities in classroom (Falk & Dierking, 2012; Rennie, 2007; Rennie & McClafferty, 1995).

Information technology can support learning in school, and outside school (Siemens, 2005). Learning management systems such as Moodle provide a means for dialogue, discussion, and interactive debate that leads to the social construction of meaning (Driver, Asoko, Leach, Mortimer & Scott, 1994; Lynman, Billings, Ellinger, Finn & Perkel, 2005). Students can 'talk' with other students, teachers, and professionals in communities far from their classroom. These discussions are typically guided by teachers who post questions on a *forum*. However, systems like Moodle can be used for increasing student collaboration and communication where they become self-directed, negotiating their own goals, expressing meaningful ideas and display a strong sense of collective ownership (Scanlon, Jones & Waycott, 2005; Willett, 2007).

The learning institution involved in this inquiry comprised of a secondary school in a small town, in a wealthy dairy farming area in a rural district in New Zealand. The secondary school was co-educational in a high-decile suburb (decile rating 10). The decile rating of a school is a measure of the school community socio-economic status, and communities are rated on a scale of 1 to 10, with 1 being poorest and 10 wealthiest (Ministry of Education, 2015). Section 1.7, which follows, outlines the organisation of the thesis.

1.7 The Organisation of the Thesis

This thesis is organised in seven chapters. Chapter 2 comprises the first part of the literature review. It consists of a review of relevant literature of science education inquiries, namely theories of learning, types of learning such as formal, informal (free choice) and non-formal, learning sites and learning experiences outside school. Chapter 3 explains the theoretical basis used for the inquiry on pedagogies (new teaching strategies); technology enriched teaching style, learning design and emerging technologies, new media literacies (NML), and the use of learning management systems (LMS). In Chapter 4, the methodology conducted in the inquiry is explained in terms of the belief system of the inquiry, the research design, data collection and analysis. The data analysis procedures are described next, along with a description of measures taken to maintain the trustworthiness of the inquiry.

The chapter concludes with a consideration of the ethical issues pertinent to the inquiry. The research findings based on interviews, classroom observations, ISI visits, Moodle postings and curriculum documents are reported in Chapters 5 and 6. The format for the presentation of the results and discussion follow that of the research questions outlined in Section 1.3 (p. 4) with current practices for LEOS in secondary schools and students and teachers use of digital space in preparing students for LEOS. The thesis concludes with Chapter 7, which consists of discussion and conclusions, together with limitations and implications of the inquiry for teaching and learning using LEOS programs along with suggestions for future research. Section 1.8, which follows, provides the Chapter summary.

1.8 Chapter Summary

This chapter has provided an introduction to the inquiry and the use of LEOS programs in science teaching and learning. The background and justification were described first and used to provide the research development in this area of study. A description of the assumptions and definition of relevant terms followed, and the chapter concluded with comments on the significance of inquiry into LEOS, the context of the inquiry, and the organisation of the thesis. Chapter 2 provides a theoretical basis for the study by reviewing relevant studies in science education about modern theories of learning, types of learning, learning sites and LEOS.

CHAPTER TWO
LITERATURE REVIEW: RELEVANT STUDIES IN SCIENCE EDUCATION

Overview of the Chapter

This chapter comprises a review of relevant studies from the science education literature, focusing on the research questions described in Chapter 1 (p. 4). This inquiry is concerned with investigating ways of enhancing students' science learning experiences outside school. Section 2.1 discusses different theories of learning. Section 2.2 considers relevant research related to research question one, and comprises a review of reports on the different types of learning; formal, non-formal and informal, which occur in the different contexts such as in classrooms and at Informal Science Institutions (ISIs). Section 2.3 further explores the literature about research question one, focussing on learning at ISIs. The chapter concludes with, Section 2.4, which discusses the use of LEOS at ISIs such as museums, observatories and zoos that provide interactive experiences for students, helping them connect science to everyday life. Section 2.1, which follows, discusses the different theories of learning.

2.1 Theories of Learning

Modern theories of learning have resulted in a shift in thinking from viewing learning as occurring by transmission, to learning conceptualised as the construction of knowledge in a particular social context. Hence, this chapter begins with a discussion of behaviourist or traditional theories of learning and their origins, followed by discussion of modern theories of learning; viz., constructivism, social constructivism, and sociocultural theories of learning. These models are being tested in classrooms, in other words they can be used as a referent to building models for learning, teaching and curriculum. The final part of this section considers how theories of learning may be used as a *referent* for teaching, and how we should look at both teacher and learner roles in order to plan and implement activities that enhance learning. Section 2.1.1, which follows, discusses behaviourist or traditional theories of learning, and their origin.

2.1.1 Behaviourist or Traditional Theories of Learning and Their Origin

All theories of learning originate from different paradigms or belief systems that are based on ontological, epistemological and methodological assumptions (Cohen, Manion & Morrison, 2007; Guba & Lincoln, 1989; Patton, 1990). Whilst there are many 'paradigms' identified in the literature, authors such as Gage (1989) and Schubert (1986) suggest that these distil down to three main research paradigms: (a) the scientific, normative or positivistic paradigm, with its emphasis on quantitative methods, (b) the interpretive paradigm (discussed in detail in Chapter 4), with its emphasis on qualitative methods (sometimes called anti-positivist paradigm), and (c) the critical paradigm, based on critical theory, which seeks to promote social justice and social change.

Behaviourist theory was the dominant theory of learning in the first half of the last century (Duit & Treagust, 1995). The positivistic paradigm, from which behaviourism originates, considers human behaviour to be rule-governed, or a response to either an internal or external stimulus, and here learning and teaching is investigated using the methods of the natural sciences (Douglas, 1973). In contrast, the interpretive (also known as the anti-positivist paradigm) is characterised by a concern for the individual, and seeks to understand the subjective world of human experience. In this case efforts are made to get 'inside the person', and to understand from within.

Positivism historically was associated with the nineteenth century French philosopher, Auguste Comte, who was the first thinker to use the word to specifically identify a philosophical position (Cohen et al., 2007). His notion of positivism sees observation and reason as a means of understanding behaviour, and he considers that explanation proceeds by way of scientific description. Oldroyd (1986) says:

> It was Comte who consciously "invented" the new science of society and gave it the name to which we are accustomed….For social phenomena were to be viewed in the light of physiological (or biological) laws and theories and investigated empirically, just like physical phenomena. (p. 9)

Comte's position, which led to the general doctrine of positivism, held the view that knowledge was based on sense experience, and can be advanced only by means of observation and experimentation. Following the empiricist tradition, it limited inquiry and belief into what can be firmly established, thus abandoning metaphysical and speculative attempts to gain knowledge by reason alone. Positivism implies a particular stance concerning a researcher as an observer of social reality (Cohen et al., 2007). It involves a definite view of researchers as analysts of their subject matter.

Positivism claims that science provides us with the clearest possible ideal of knowledge. This paradigm is then based on the assumption of *determinism*, which means that events have causes and are determined by other circumstances, and that science proceeds on the beliefs of these causal links that can eventually be uncovered and understood. The second assumption is that of *empiricism*. This means that reliable knowledge can only be derived from experience, which provides evidence and yields (preferably empirical) data. The third assumption underlying the work of the scientist is *parsimony*, which consists of providing the most economical (i.e., parsimonious) explanation. The final assumption of positivism is that of *generality*, which plays an important part in both the deductive and the inductive methods of reasoning, and here observations made are used to generalise their findings to the world at large. This view is deemed desirable because positivists are concerned with explanations of human behaviour in a general sense. Learning in this paradigm is called behaviourism, and is viewed as the transmission of knowledge from the teacher to the learner, within a reward-based framework. Based on behaviourism up to the 1970s, the focus in educational research was on whether or not teaching practices or curriculum design resulted in changes in student academic performance (i.e., behaviour), rather than how this knowledge was acquired (Duit & Treagust, 1998); in other words, such research was very outcomes focussed. The literature claims that curricula design based on behaviourist theory were not particularly successful, saying students did not often display the expected or intended learning outcomes; this dissatisfaction with positivism and behaviourist theory led to the development of other learning theories (White, 1987).

The dissatisfaction with positivism and behaviorist theories of learning led to deeper consideration of how students learn. One conclusion drawn was that, what the student brought to the classroom greatly influenced their learning. Ausubel and Novak in the 1960s emphasised the importance of student's preinstructional conceptions as an important part of the learning process. Ausubel believed that information is stored hierarchically in the brain; new information is linked to extant knowledge and all knowledge comes from an individual's sensory experiences. A key to applying these concepts to learning were Ausubel's ideas of 'meaningful' learning as compared to 'rote' learning characteristic of behaviourism, which he felt is of limited use to the learner. This is summarised in Ausubel's famous quote: "The most important single factor influencing learning is what the learner already knows" (Duit & Treagust, 1998, p. 19). Given its importance, Section 2.1.2, next discusses constructivism in more detail.

2.1.2 Constructivism

Constructivism is a theory of learning concerned with the internal processes associated with learning. Piaget's work with his strong epistemological concerns was very influential in the development of cognitive based interest in learning, as was the work of Giambattista Vico (1644-1744), who is seen by some as the pioneer of constructivism (von Glasersfeld, 1995). While there are many forms of constructivism, a common thread is the metaphor of building up or *constructing* structures from preexisting knowledge (Spivey, 1995; von Glasersfeld, 1995). The metaphor presents understanding as the building of mental structures, and the term restructuring is often used as a synonym for accommodation or conceptual change (Kieren & Pirie, 1991; Lincoln & Guba, 1985; von Glasersfeld, 1995). The metaphor of construction as described by von Glasersfeld is seen as a process where "knowledge is not passively received but actively built up by the cognizing subject" (von Glasersfeld, 1995, p. 462). In other words, the receiver of information has to interpret new information and tries to make sense of it based upon his or her past experiences and understanding. According to the literature (e.g., Duit & Treagust, 1995; Pintrich, Marx & Boyle, 1993; Poser, Strike, Hewson, & Gertzog, 1982; Prawat, 1992; Tobin & Tippins, 1993; Wheatly, 1991) those who subscribe to a constructivist view of learning identify with Piaget's (1964) theory that new knowledge is *assimilated* (i.e., accepted into receiver's knowledge framework without much modification) or that new knowledge must be *accommodated* (i.e., the new information and/or existing mental framework need modification to fit together and make sense to the receiver).

In contrast to positivism, which seeks to maintain that there is a set reality that we are to discover, constructivism claims that reality is known only in a personal way that makes sense to the individual (Tobin & Tippins, 1993; von Glasersfeld, 1993, 1995). Therefore, the focus shifts from finding the "truth" to "viability" - what works in the user's world. Since an individual is part of a social world, viability also must fit into the individual's social context. Since the 1990s, there has been growing attention to the social aspect of learning (Duit & Treagust, 1998). The emphasis on the role of language and social environment in learning, led to the development of variants of constructivism, namely, social constructivism which is discussed in Section 2.1.3.

2.1.3 Social Constructivism

There are several variants of constructivism based on the type of research conducted or the philosophical stance of the researcher (Bettencourt, 1993; Good, Wandersee & St Julien, 1993; Nussbaum, 1989; Schwandt, 1994; Tobin & Tippins, 1993). Good et al. (1993) identified a total of 15 different adjectives used to explain the term constructivism. Two of these variants namely, radical and social constructivism are discussed in this section. Radical constructivism, championed by Ernest von Glasersfeld, is perhaps the most contentious form of constructivism (Bettencourt, 1993; Tobin & Tippins, 1993; von Glasersfeld, 1993). Wheatly (1991) describes this view, meaning that an individual can *only* know the world through his or her own experiences. This means that knowledge transmission is impossible even in principle, and that there is no way of checking reality against what it was supposed to represent. This is problematic for many scientists who most likely hold empirical-positivist beliefs. Bettencourt (1993, p. 47) summaries the situation succinctly when he states that "radical constructivism shows us that the relationship between our knowledge and our experience is, at best undetermined".

Another variant of constructivism as mentioned above is social constructivism. The importance of social interactions was noted by Vygotsky (1986), who shared many of Piaget's assumptions about how children learn, but placed stronger emphasis on the social context of learning, and this forms the basis of social constructivism. According to Vygotsky, both adults and older or more experienced children, play important roles in learning. Vygotsky's 'brand' of constructivism is termed social constructivism, because he emphasized the critical importance of culture and the importance of the social context for cognitive development. He argues that students can, with the help from adults or other children who are more advanced, master concepts and ideas that they cannot understand on their own.

Learning is inextricably related to the social setting (and this need not be a classroom), where students actively participate and create new meanings (Biggs, 1999; Falk & Dierking, 2000; Goodrum 2007; Preston & Rooy, 2007). This view suggests that students may enjoy learning more when engaged in socially mediated learning activities where they have choice and some control over their learning (Griffin, 2004; Scott, 1998). Consistent with this view, Falk and Dierking (2000) and Paris (1997) argue that student's value autonomy and independence of learning, and this may be easier to achieve in less formal environments such as those in out-of-school settings, called ISIs. This is discussed in more detail in Section 2.2 below.

According to Gergen (1995) social constructivism does not commence with the external world as its fundamental concern as in the *exogenic* case (i.e., thinkers often place a strong emphasis on observation in the acquisition of knowledge). He states that an exogenecist is also likely to stress the importance of knowledge as the ability of the individual to adapt to or succeed within a complex surrounding. *Endogenecists*, believe that knowledge is a mental state which can be enhanced by reasoning, logic and conceptual processing all of which can be achieved through the use of language. Learning then occurs by a process of social interchange (Gergen, 1995; Shotter & Gergen, 1994) and social constructivism places the human relationships in the foreground (i.e., the pattern of interdependent action at the micro-social level). Gergen (1995) goes on to say that from a social constructivist standpoint, meaning is achieved through the coordinated efforts of two or more persons where language serves as an external expression of internal states of mind.

According to social constructivists, learning in a classroom occurs when the teacher provides appropriate tasks and opportunities for dialogue, and guides students to construct their own knowledge through social discourse involving explanation, negotiation, sharing and evaluation (Clements & Battista, 1990; Tytler, 2004). This view is supported by Tytler (2004) who argues that social constructivism sees language and culture as fundamental requirements for the construction of knowledge.

In summary, social constructivists believe that an important part of knowledge construction is social interaction, through which we come to a common understanding of knowledge (Solomon, 1995; von Glasersfeld, 1993; Wheatley, 1991). Some authors argue that cognition is distributed among individuals, and that knowledge is socially constructed through collaborative efforts to achieve shared objectives. These authors feel that social constructivist theories of learning did not pay enough attention to the social component and this led to the social cultural theories of learning which are discussed next in Section 2.1.4.

2.1.4. Sociocultural Theories of Learning

The sociocultural approach assumes that mental functioning is inherently situated with regard to cultural, historical and institutional contexts (Wertsch, 1991; Wertsch & Toma, 1995). Sociocultural views of learning propose different understanding of the 'social' contribution to learning, and acknowledge the influences of Vygotsky and Piaget, along with more recent contributors such as Lave, Wenger, and Rogoff (Salomon & Perkins, 1998). Vygotsky and Piaget viewed the individual mind as developing in a socially-mediated environment (Piaget, 1950; Vygotsky, 1978; Wertsch, 1991), whereas Lave and Wenger (1991) view learning as comprising of social practices, rather than purely cognitive processes. Key to these social practices, according to Rogoff (1991, 1995), learning occurs through participation. These sociocultural perspectives thus consider learning as a situated activity occurring through participation, as distributed cognition, and via mediated action.

The first of these ideas depicts learning as a situated activity within a community of practice (Lave, 1991; Lave & Wenger, 1991; Wenger, 1998). In this view of learning and thinking, members participate in a shared endeavour which Lave (1991) called *legitimate peripheral participation* (LPP). Lave (1991, p. 14) defines situated learning as emphasizing "the inherently socially negotiated quality of meaning and the interested, concerned character of the thought and action of persons engaged in activity." She also claims that learning, thinking, and knowing are relations among people engaged in activity, in, with, and arising from the socially and culturally structured world. That is, learning occurs within a social situation from which it cannot be dissociated, and can only be understood within the context in which it occurs. The emphasis on social negotiation of meaning highlights the interactional mode of learning in which participants share knowledge and understanding to reach a joint construction of knowledge (Rogoff, 1991, 1995).

A second view of learning that underpins sociocultural views of learning is distributed cognition across a community of practice. The notion of distributed cognition suggests that learning is seen to involve more than just the person, but the "person-plus" (Perkins, 1997), being the person plus the "surroundings." From this perspective, cognition (and learning) is seen to be located outside individuals' heads, and jointly composed in a system of people and artefacts (Brown, Collins & Duguid, 1989; Salomon, 1997). Distributed cognition therefore includes the physical and social resources of the setting that serve as a "vehicle for thought," and what is learned, situated both in the mind of learner and in the "arrangement of the surround" (Perkins, 1997, p. 89). This notion is further supported by Brown et al. (1989) who emphasise that construction of meaning is tied to specific contexts and purposes, and that it is important to provide an authentic practice through activity and social interaction for development of understanding.

The third notion that contributes to sociocultural views of learning is that human action is mediated action with learning mediated by tools and signs (Bell & Cowie, 2001; Vygotsky, 1978; Wertsch, 1991). This view draws on the work of Vygotsky (1978), and mediated action considers that human action such as learning is affected by psychological tools and signs, which are themselves situated in the social and cultural environment in which they exist (Wertsch, 1991). Wertsch (1991) further asserts that one way of investigating sociocultural approaches to how the mind works is through exploring how social language mediates learning (e.g., writing or speaking 'scientifically'), that is specific to the sociocultural context in which learning occurs.

This constitutes one of the psychological tools identified by Vygotsky. Other psychological tools include technical tools like scientific equipment and processes (see Eames & Bell, 2005).

In summary, constructivism is a theory of learning where the teacher seeks to create a classroom environment which draws upon students' prior knowledge in which social interactions as noted above are used to negotiate meaning, with provisions made for a variety of sensory experiences. Radical constructivism views learning as a personal construction, while social constructivism places emphasis on social setting and learning occurring in socially mediated environment where participants have some control and choice. Sociocultural theories of learning consider social practice where learning is considered as a situated activity through legitimate peripheral participation. The interactional mode of learning helps participants' share knowledge and understanding to reach a joint understanding of the concept. Given the importance of constructing knowledge through social participation, Section 2.1.5 which follows, discusses constructivism used as a referent for teaching.

2.1.5 Theories of Learning as a Referent for Teaching

As noted above, learning theories can be used as a referent for teaching, and this helps us understand what influences students' prior conceptions have on teaching, learning and the types of assessment used. Assessment here is integrated within the teaching and learning process, and is used to see if the intended learning outcomes have been achieved during the lesson (Gunstone, 1995). A constructivist-based model of teaching sees the teacher as a facilitator of learning; a shift from teaching by imposition to teaching by negotiation (Bodner, 1986). While it is important to elicit student's prior knowledge, it is equally important to provide opportunities or affordances in the classroom for social discourse (Gibson, 1979). This suggests that the role of student's preinstructional conceptions is important in learning. It seems that all too often these conceptions are not in accord with science concepts or intended learning outcomes and are highly resistant to change (Duit & Treagust, 1995). How these preinstructional conceptions can be diagnosed and how teaching can be designed to take students conceptions into account will likely play key roles in the learning process, since the literature suggests that the acquisition of new knowledge is influenced by ideas already held by students (Duit & Treagust, 1995; Hanson, 1965; Kuhn, 1970; Tobin & Tippins, 1993).

The influence of students' preinstructional conceptions on learning is supported by Pintrich, Marx and Boyle (1993) who suggest that open-ended classroom activities facilitate cognitive development and conceptual change of preinstructional conceptions best when students are offered choice and some control over their learning. This is consistent with social constructivist theories of learning, where the teacher provides appropriate tasks and opportunities for dialogue, and guides students to construct their own knowledge through social discourse involving explanation, negotiation, sharing and evaluation (Clements & Battista, 1990; Tytler, 2004). Nussbaum and Novick (1982) along with Rowell and Dawson (1984) say that practical activities supported by group discussions provide physical experiences that induce cognitive conflict which encourages students to develop new knowledge. That is the learner experiences teaching and learning situations and gives personal meaning to those experiences through their own reflection, and through social interactions with other students and teachers.

These experiences are not considered solely as the encoding of environmental features into the perceiver's mind, but as an element of an individual's interaction with his/her environment. These interactions between a student and the environment, inherent conditions or qualities of the environment allow the student to perform certain actions with the environment (Gibson, 1979). The properties of the environment that present possibilities for action are available for a student to perceive directly and act upon. Greeno (1994) uses the term *affordances* to represent preconditions for activity and that while they do not determine behavior, they increase the likelihood that a certain action or behavior will occur. This is consistent with what Hawkins (1994) said and John Dewey emphasised; the need for teachers to investigate student's individual talents and provide opportunities and assorted resources to extend their potential. This represented the beginning of constructivist-based approaches to teaching and learning. Bruner (1960) identified four themes derived from constructivism that he thought needed to be explored in science education: (a) placing emphasis on structure rather than facts and techniques; (b) readiness for learning especially for new ideas; (c) analytical thinking based on inquiry based learning; and (d) stimulating learning environment. Hawkins (1994) noted that elucidation of students' conceptions in science gained priority in the middle of the 1970s which led to the rethinking of science instruction (Duit & Treagust, 1995). As a consequence, the constructivist view became a significant influence in assisting our understanding of students' learning difficulties and in developing new teaching and learning approaches. Duit and Treagust (1995) suggested that the constructivist view of learning has had a significant influence in assisting our understanding of students learning difficulties and hence we need new teaching and learning models. Two of these teaching and learning models namely; *metacognition* and *teaching with analogies* are discussed next.

Metacognition is where students compare their new ideas with earlier ones, gradually becoming aware of how they learn. In this case, teachers' and students' conceptions of their own learning process play a key role in learning from a constructivist perspective. Novak and Gowin (1984) along with White and Gunstone (1995) suggested the use of concept maps to probe students' understanding and elicit the relations each student perceives between different concepts as a way of enhancing metacognition. This type of approach could be either used as a teaching pedagogy or as an assessment tool. However, it is important to note that this approach takes time and requires training, but it can be a useful tool for both students and teachers to evaluate the level of student understanding.

Teaching with analogies involved explaining abstract ideas by using familiar ideas. The usefulness of analogies as teaching aids is reinforced if other teachers also use this approach during their lessons, but students also require training in order to understand and use analogies well (Harrison & Coll, 2008). The everyday object is called the *analog*, the scientific concept is called the *target* and the structural or functional relationships made between them are called *mapping*. These mappings consist of *shared, unshared, neutral* and *irrelevant* attributes. The literature suggests that a teacher should be cautious when using analogies for teaching since uncritical use can create alternative conceptions (see Glynn, 1991; Harrison & Coll, 2008). The FAR *(Focus, Action, Reflection)* guide provides a systematic approach to teaching using analogies (Venville, 2008a, 2008b). Çalik, Ayas & Coll (2009) found that analogies improved students' conceptual understanding for solution chemistry.

2.1.6 Section Summary

The discussions above has highlighted the fact that there are three main theories of learning, behaviourist or traditional, constructivist, and sociocultural theories of learning. As noted above, constructivist views of learning have been used as a referent for teaching and learning. Social constructivism, which is a variant of constructivism, focuses our attention on the social processes operating in the classroom by which a teacher can promote a learning community in which students and the teacher ‘co-construct’ knowledge. The sociocultural theories of learning consider social practice where learning is considered as a situated activity through legitimate peripheral participation. There is now sufficient evidence to suggest that constructivist teaching principles can influence classroom practice and thereby influence student learning of science. Section 2.2, which follow, discusses the definition and characteristics of different types of learning, formal, non-formal and informal.

2.2 Types of Learning

There are three broad types of learning identified in the literature: *formal, non-formal* and *informal.* This Section, discusses the literature on the definitions and characteristics of these, along with reported benefits and issues of including informal science education in formal science teacher preparation programmes. *Figure 2.1* shows the three types of learning, their characteristics, and relevant examples of formal, non-formal and informal education.

TYPE	Characteristics			Example
Formal	School (attendance)	At school Out-of-school	Organized	Regular lessons at school, a class visits a museum (organized by the teacher) a class visits the university for a project week (example)
Non-formal	Voluntary	Out-of-school and Free-choice	Organized	Summer school, science courses in the students’ free time
Informal	Voluntary	Free-choice	Not organized	TV, visiting a zoo on Sunday…

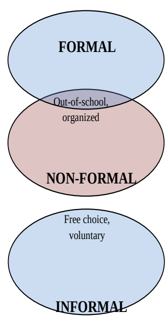

Figure 2.1: Types, characteristics and examples of learning according to Coll, Gilbert, Pilot & Streller, 2013.

According to Coll et al. (2013), education in the compulsory, *formal* sector is characterised by:

- Being involuntary (i.e. students are required to attend);
- Providing students with very limited choices, if any, of what and when they study;
- Often providing instruction that is by transmissive (didactic) methods;
- Often involving students normally working alone;
- Managed students in groups that are homogeneous in age and attainment;
- Regular and rigorous assessment of what students have learnt; and
- Being under the close control of a teacher.

According to Coll et al. (2013), education in the *informal* sector is characterised by:

- Being entirely voluntary as regards to participation;
- Providing a wide choice of what can be studied, and when;
- Providing instruction in a wide variety of methods, few of which are transmissive;
- Enabling students to work either alone or in groups of their own choosing in terms of age and attainment;
- Only involving assessment, if any, that is for the immediate benefit to the student; and
- Not being under the close control of anybody with the role of a 'teacher'.

Section 2.2.1, which follows, discusses definitions and characteristic of formal learning.

2.2.1 Definition and Characteristics of Formal Learning

Coombs and Ahmed (1974) equate education with learning, and identify three types of learning: *formal*, *non-formal* and *informal* (Figure 2.1). Formal education is defined as "institutionalised, chronologically graded and hierarchically structured educational system" (La Belle, 1982, p. 162). Formal learning takes place in formal institutions of an educational system like schools, or post-compulsory education systems such as vocational training institutions, polytechnics, institutes of technology, and universities (Coll et al., 2013; La Belle, 1982), and is characterised by formal, structured lessons that mostly occur in classrooms.

Formal learning is characterised by being teacher-centred in a highly structured classroom, following a prescribed curriculum as well as having a strict assessment regime (Figure 2.1). In formal learning contexts such as in classrooms, teachers are mainly concerned about conceptual change and/or the learning of new concepts. The literature suggests that efforts to teach science in classrooms is characterised by a teacher-dominated classroom, and by rote learning of concepts or facts, mere copying, and a general lack of understanding (Muralidhar, 1989; Newton, Driver & Osborne, 1999; SoonChunLee, 2012; Taylor, Taloga & Ali, 2008).[1] Aikenhead (2006), Calabrese Barton (1998) and Costa (1995) suggest that traditional school science often fails to engage science students especially those from particular cultural and socioeconomic backgrounds, and argue that declines in student enrolment in science is due to disenchantment with the subject (Aikenhead, 2006; Fensham, 2004). An examination of the science education literature suggests this is prevalent in both developing (see Coll & Taylor, 2009) as well as in developed countries (Braund & Reiss, 2006). Hewson (1988) noted that although far more children in developing countries study science than in Western nations, research suggests that a great majority do not master more than a small portion of the goals set for them. For example, observations of classroom teaching practices show a combination of nature of the power relationship that exists between science teacher and student and the rhetorical project of the science teacher which seeks to establish the consensually agreed scientific world-view with the student, means that opportunities for dialogic discourse are minimised. Hence, students are rarely involved in the lessons, and so there is a need to shift away from this normative nature of classroom discourse (Muralidhar, 1989, Newton, Driver & Osborne, 1999; SoonChunLee, 2012). The problem of extremely didactic science teaching in many countries has been exacerbated by an intense regime of summative examination. Vulliamy (1988) reported that the content and style of the national examination tend to be more important determinants of the content and process of teaching than the syllabus (see also Newton, Driver & Osborne, 1999; SoonChunLee, 2012; Taylor, Taloga & Ali,

[1] However, there have been major reforms seeking to change this, which are discussed below

2008). Improved science education has been placed high on the agenda of tasks to be tackled in many countries, particularly developing countries (Kahn, 1990; Kirkpatrick & Zang, 2011; Rombo, 2008; Taylor, Taloga & Ali, 2008), because it is believed that science education has the potential to help improve living conditions through addressing local problems with respect to basic needs such as clean water, sound nutrition and personal health (Lewin, 1993). However, any change will require teachers to be convinced that classroom discourse is an essential component for the learning of science which requires a range of pedagogical strategies which will both initiate and support social construction of knowledge.

As discussed in Section 2.1, the definition of learning is usually strongly aligned with the researcher paradigms, embedded in their ontology (belief about the nature of truth and reality) and epistemology (belief about how knowledge comes into being). What one believes about the nature of truth and nature of knowledge influences one's definition of learning, and what 'counts' as learning (Anderson & Ellenbogen, 2012).

As noted above, there has been recent shift in thinking about how students learn. This view about learning resulted in worldwide curriculum reform, a shift from formal curricular in many countries to developing learner-centred curricular where there is more variety in the methods of providing instruction (see Figure 2.1). This move represented a deliberate attempt to shift from teacher-dominated highly structured classroom learning to more flexible learning that takes into account students' prior conceptions and interests, and in which teachers are expected to focus on the learner not on delivery of mass content. That is, providing more choices of what is to be studied, where these studies are done, as well as providing opportunities for students to become responsible for their learning.

An example of how some countries have tried to shift away from traditional pedagogies is in New Zealand, the context for this inquiry. New Zealand began substantial curriculum reforms in 1991, when the science education system in New Zealand went through a massive redevelopment programme, with curriculum statements replacing syllabuses (Science in the New Zealand Curriculum, 1993, [MoE]). The current curriculum provides a framework of learning of science for all students and places strong emphasis on teaching approaches based on a constructivist based view of learning, which requires teachers to provide opportunities for a variety of learning experiences for science. LEOS is intended to help enrich student learning experiences, motivate them to learn science, encourage life-long learning as well as providing exposure to future careers (Hofstein & Rosenfeld, 1996; Tal, 2012; Tal & Steiner, 2006). Hence, on paper at least, formal education can and does include LEOS, a shift from pure classroom learning, and is expected to be more learner-centred than in the past. Section 2.2.2, next discusses definition and characteristics of non-formal learning.

2.2.2 Definition and Characteristics of Non-Formal Learning

In addition to informal and formal learning, Tofield et al (2003) speaks of non-formal learning as any form of organized education (Figure 2.1) occurring outside the classroom, defined as learning which is generally voluntary and features affordance for social interactions, which assist learning. They further go on to say that only opportunities that are taken advantage of during leisure time, like summer schools, should properly be considered to be non-formal learning. However, introducing resources into the classroom laboratory such as TV programmes, newspaper reports, inviting guest speakers are ways for non-formal learning to supplement the traditional classroom practices. Visits to science centers, museums and zoos collectively known as Informal Science Institutions (ISIs), where learning is formally organized, also allows for non-formal learning (Coll et al., 2013; Tofield, et al., 2003).

The literature suggests that non-formal learning is characterised by learning which need not be confined to the classroom (Figure 2.1), and employs a variety of methods for providing instruction and enables choice in learning. Useful learning, it is argued, may occur in unexpected places involving non-formal learning processes. Some examples of practice which encompass non-formal learning range from learning via digital media such as television and computer websites to visiting museums and zoos, where work is organized by the teachers but students could visit these ISIs during their free time to complete class task, with some degree of choice on the animal to be studied. For many students, the Internet is a source of non-formal information, where they have to filter a huge range of materials available on almost any topic. The digital medium is also used as a social networking medium where students interact with each other, and the learning varies enormously.

There is, however, little research on informal learning via a digital medium and on how learning occurs and how it might be facilitated (Coll et al., 2013). Since, the learning environment has changed rapidly and dramatically, digital media has become an important part of most people's everyday communication. Additionally, students have grown up in the digital age and cannot imagine a world without digital media. Coll et al. (2013, p. 250) reported that "the traditional borders or walls of the school, the library, museum and science centers may be seen by students as something of an artifact from the past; related to a culture of the past."

Digital media not only help interaction between students, but interaction between students and teachers and experts (telementors). A good example is when students want to use industry as a place for out-of-school learning (see Collet al., 2013; Pintó & Couso, 2007). The dialogue between industry and school can help make lessons more practical and realistic, meaning that science classes involve exposure to more authentic science. These interactions help students and teachers to get information from experts, information on career choices, and make links between industry and society. There is a growing interest in learning that occurs outside school which allows students' control of their learning. Section 2.2.3, which follows, discusses definitions and characteristics of informal learning.

2.2.3 Definition and Characteristics of Informal Learning

Rennie and McClafferty (1996) define informal learning as flexible learning or free choice learning, and is characterised by being entirely voluntary, occurs outside school, with a wide choice of learning experiences which could be collaborated using a variety of methods (Figure 2.1). Learning in places (e.g., in zoos or science museums) where learning was deemed to be non-sequential, self-paced and voluntary in nature rather than following a set curriculum. Learning is not so much guided by the students' needs but by their interests. Other researchers use the term informal learning to describe learning experiences which are unplanned, casual, implicit, unintentional (or at least not institutionally organised), and thus always voluntary in nature (Figure 2.1) (Coll et al., 2013). Rennie (2007), Falk (2001a, 2001b), Stocklmayer, Rennie and Gilbert (2010) as well as Coll et al. (2013), define informal learning as *unconscious* and *conscious* forms of learning, that occurs outside formalised educational institutes either alone or in groups. Some of the characteristics of informal learning are given in Section 2.2, Figure 2.1, which shows some examples of the same.

The literature thus suggests that informal learning is characterised as voluntary learning which occurs outside school. Bransford, Brown and Cocking (2000) as well as Crane (1994), include home environment as another context for informal science education, pointing out that interactions with family members provide early science learning opportunities and establishes a supportive learning environment. Falk and Dierking (2000) are of the opinion that learning experiences outside school are rather idiosyncratically contextualised, and suggest that such learning takes a lot of time since it involves students' prior experience and is enhanced by social interactions among students. These social interactions are the central constituent of learning according to the social constructivist theory described earlier in Section 2.1, and social constructivism has become a leading theory with respect to learning in informal settings (Rogoff, 2003).

Informal learning is also characterised by the nature of free choice in learning and which is learner-centred (Figure 2.1). Tofield et al (2003) drew upon work by Falk and Dierking (2012), and Bamberger and Tal (2007), and used the phrase *free choice learning* (discussed further in Section 2.3.2) to describe informal learning. Consistent with the views of Falk and Dierking (2012), and Bamberger and Tal (2007), informal learning is then seen as learning that occurs outside the context of formal or compulsory school learning and that involves *at least some* free choice. Informal learning is student-centered and is driven by personal, social and physical contexts which help motivate students and has a positive influence on their learning (Falk & Adelman, 2003; Falk & Dierking, 2012; Falk, Randol & Dierking, 2008; Roschelle, 1995).

The literature suggests that informal learning is characterised by students working in groups and collaborating with each other using a variety of methods (Figure 2.1). Informal science programmes are characterized by opportunities for participants to interact with one another and guide their learning. Conversations with others in their own social groups and with those outside one's social group such as ISI staff and other visitors influences learning (Ellenbogen, Luke & Dierking, 2004; Fienberg & Leinhardt, 2002; Leinhardt, Crowley & Knutson, 2002; Rosenthal & Blankman-Hetrick, 2002). These informal programmes also are characterized by being primarily concerned with variables related to the affective domain of learning. Meredith, Fortner and Mullins (1997) as well as Dori and Tal (2000) say that the goals of informal science education programmes focus on fostering positive attitude, improving confidence of doing science and encouraging individuals to participate in science. These programmes could be either visits to ISIs or using different forms of communication media. These collaborations using mass media particularly news media, play an important role in informal learning especially with regards to science and environment. Coll et al. (2013), along with Falk and Dierking (2012), argue that newspapers and magazines, popular books which are readily available in multiple commercial outlets, films, television and video are sources of science information which provide for informal learning. However, the use of the Web has become a major source of social medium that is used for informal learning. The use of the digital medium for communication and interaction has become in a short time a normal daily activity for most people especially students.

Since collaborative or group learning characterizes informal learning (Figure 2.1), students do inquiries on specific topics of interest, study in teams, use the Internet for sources of information, interact in an Internet symposium involving peer review of their reports and even publish results on the Internet (Ryoo, & Linn, 2012; Van Rens, Pilot & Van de Schee, 2010). Given the current trend that indicates the Internet and other digital media are increasingly supplanting television as a primary way youth spend their free time, it is reasonable to assume that the impact of digital media on science learning will become increasingly important (Yelland & Lloyd, 2001). While a lot of research has focused on improving the quality of online learning resources, Dede (2005) alerts us on how, why and to what end, people use the Internet to learn. All of these opportunities represent important, indeed essential, ways that we can learn and most importantly contextualize our science knowledge and understanding. Therefore, it is critical that we recognize, understand and learn how to facilitate informal learning as a powerful vehicle for lifelong science learning. Although the idea of informal learning is appealing, research shows that meaningful learning is associated with limited choice patterns (see Section 2.3.2). Finally, in order to shift away from traditional classroom practices which were predominantly teacher-centered to a more learner-centered curriculum, there is a need to equip teachers with relevant skills to embrace and utilize a more flexible learning environment. This initiative would require changes to the current teacher preparation programmes. Section 2.2.4, next discusses some benefits of including informal science education settings in science teacher preparation.

2.2.4 Benefits of Including Informal Science Education Settings in Science Teacher Preparation

A number of studies have reported that inclusion of informal science education settings or ISIs in science teacher preparations provides benefits to preservice teachers programs (Anderson, Lawson & Mayer-Smith, 2006; Gupta & Adams, 2012; McGinnis, Hestness, Riedinger, Katz, Marbach-Ad Dai, 2012; Olson, Cox Peterson & McComas, 2001; Yarrow, Millwater & Fraser, 1997). These include the development of positive attitudes (e.g., value, interest, excitement for science including respect for life), an open mind for change, and confidence in teaching. Inclusion of informal science education is also thought to help in the development of science skills in preservice teachers as they experience teaching in diverse contexts relating to the diverse needs of students. Another reported benefit was autonomy of their learning, since ISIs allowed the development of deeper understanding of learning theories, hence diversifying their teaching strategies. Other affective benefits included more collaboration between preservice teachers, allowing them to gain a broader perspective on science teaching and learning from each other, gain in scientific knowledge and development of professional skills and exposure to a wide variety of teaching resources (Chesebrough, 1994; Ferry, 1995; Kelly, 2000).

Some reported benefits of the use of informal learning for preservice teacher preparation are that an ISI based teaching practicum experience improved attitude towards science teaching. It not only makes science fun and relevant to the lives of preservice teachers, but has a high impact on their curiosity and interest in science (Chesebrough, 1994; Ferry, 1995; Kelly, 2000). A number of studies have also suggested that an increased interest in science and improved attitude towards science teaching can also lead to higher levels of self-efficacy and self-confidence in teaching, which helps preservice teachers to make sound educational judgements (e.g., Anderson, Bethan & Mayer-Smith, 2006; Ferry, 1995). It has been documented that the nonthreatening and supportive nature of the ISIs was a significant factor in helping preservice teachers gain confidence. Both Kelly (2000) and Jung and Tonso (2006) researched a museum as an ISI for preservice practicum. It seems then that these different learning contexts facilitate a sequence of experiences which promote confidence about science teaching.

The literature suggests that another factor which contributes towards feeling confident about science teaching is working with small class sizes or groups, which allows for more meaningful interactions with individual students. This leads to increasing confidence in terms of preservice teachers' perceived ability to assess student progress. Jung and Tonso (2006) together with Spencer, Cox-Petersons and Crawford (2005), say that by teaching in ISIs, preservice teachers are able to spend more time actually teaching science and gaining experience with appropriate pedagogical strategies for diverse students compared to formal classroom internship/practicum settings. Preservice teachers are able to learn more about the students' background and how their science learning, cognitive development, and behaviour progresses from younger to older grade levels. This also helps the preservice teachers to build student management skills which are skills transferable to the classroom but also necessary for leading students during LEOS.

As mentioned above, another feature of informal learning is experiencing teaching in a diverse context, at ISIs, which is reported to help develop a positive attitude towards teaching science. Preservice teachers who have taught in ISIs displayed an increased sense of autonomy (Anderson et al., 2006; Chin, 2004; Jung & Tonso, 2006; Kelly, 2000). Since learning in such environments is more self-directed and less structured than classroom environments, preservice teachers often have the freedom to make independent decisions and adopt new approaches to science teaching (Anderson et al., 2006; Ferry, 1995; Jung & Tonso, 2006; Spencer et al., 2005). Without a site mentor, preservice teachers have opportunities for leadership roles and have to develop their own lessons and teaching methods. The learning that occurs in an informal setting allows them the freedom to make decisions about their practices with less anxiety about meeting the expectations of others as might occur in a classroom (Anderson et al., 2006; Ferry, 1995; Jung & Tonso, 2006). Teaching science at ISIs thus enable teachers to value science and science learning as a process, placing less focus on finding the right answer and more focus on actually doing science with students (Anderson et al., 2006; Kelly, 2000).

Informal science learning environments also provide preservice teachers with a broader and deeper understanding of learning theories and how these may be translated into practice (Anderson et al., 2006; McGinnis et al., 2012). With the diversity of audiences each day, such as in an aquarium setting, preservice teachers have the opportunity to truly see constructivism used as a referent for teaching (Anderson et al., 2006). Kelly (2000) together with Jung and Tonso (2006) reported that such out-of-school teaching practica helped preservice teachers develop a better understanding of constructivism as a theory of learning and its implications in teaching science. With the unique nature of the setting, being interactive and self-directed, students have unique opportunities to ask questions, and preservice teachers become aware that they have to uncover students' prior knowledge and experience and build upon. Anderson et al. (2006) likewise reported that teaching in informal environments helped preservice teachers develop broader epistemologies of science teaching, and more holistic views of education in general. While a visit to say an aquarium might focus on something specific like conservation, it also prompts preservice teachers to reflect on their own values and what is personally important to them rather than covering a prescribed curriculum. Anderson et al. (2006) concluded that preservice teacher training can be transformed by conducting practica at ISIs since it helps broaden their epistemologies and pedagogies of teaching.

The use of informal science settings such as ISIs also can facilitate science content gains (Chin, 2004; Jung & Tonso, 2006). While the benefit of content gained varies between participants depending on their background, studies suggest that including informal science teacher education into teacher preparation programs is influential in developing participants' science knowledge. This outcome it seems occurs because informal science education settings often afford more opportunities for collaboration between teachers than formal school settings (Anderson et al., 2006; McGinnis et al., 2012). This kind of collaboration allows for joint discussion and reflection among preservice teachers. In the formal setting, the preservice teacher works with a mentor in an isolated classroom. In contrast, at ISIs the preservice teachers work with one another to share ideas and reflect on effective teaching strategies (Cox-Petersen, Spenser & Crawford, 2005; Leroux, 1989; Spencer et al., 2005). This collaborative environment which included university staff and museum staff enabled them to share ideas and assess individual student progress, and to enhance their content knowledge.

Finally, another advantage of connecting formal and informal learning contexts in teacher education is the gain in professional knowledge and access to a wider range of resources (Jung & Tonso, 2006). While David and Matthews (1995) speculated about the necessary materials and equipment provided by museums for implementing hands-on activities in the classroom, Chin (2004) emphasised the importance of these resources and encouraged preservice teachers to take advantage of these resources in their classrooms. Such resources are often well documented and represent current science, something often not available or readily accessible to busy classroom teachers. While there are numerous benefits of connecting formal and informal learning contexts, there are some potential problematic aspects associated, and these are discussed next in Section 2.2.5.

2.2.5 Problematic Aspects of Including Informal Science Education in Formal Science Teacher Preparation

Although there are numerous benefits of including informal science education into formal science teacher preparations as discussed in Section 2.2.4, there are also some problematic aspects reported in the literature. There are five issues regarding the inclusion of informal science education in formal science teacher education:

(1) provision of teaching skills on limited topics only; (2) insufficient time for collaboration and learning among preservice teachers; (3) preservice teachers' lack of skill in learning across different subjects and from ISI to classrooms; (4) lack of support from other teachers at school; and (5) limited procedural and financial support from schools, all can negatively impact on learning experiences at ISIs.

Studies conducted at ISIs are seen to focus on only certain science topics which limit the extent to which participation can result in extensive science knowledge (Chin, 2004; Jung & Tonso, 2006; Leroux, 1989). These authors argue that while ISIs provides a range of resources, they are typically restricted to certain topics; For example a museum may emphasise life sciences over physical sciences. Equally, the literature reports that while there are opportunities for collaborative learning, the amount of time provided to do this is all too often very limited, so the extent of building these new skills among teachers is reduced. Furthermore, while there are opportunities to develop classroom and time management skills at these informal learning sites, preservice teachers may struggle to reinforce these skills when trying to transition between different subjects (Jung & Tonso, 2006). However, it is equally important that these preservice teachers have a disposition where they focus upon the pedagogical practices that support dialogic arguments and foster students' epistemological development.

Research also indicates that while informal learning contexts allow for better understanding of constructivism and its implications in teaching, preservice science teachers may struggle to make connections between informal practica and their formal classrooms (Kelly, 2000; Jung & Tonso, 2006). This is probably due to lack of support and encouragement from fellow teachers in a formal classroom setting, in contrast with time spent at an ISI, where they are highly supported by lecturers, and ISI staff as well as other preservice teachers. Chin (2004) observes that preservice teachers are frequently concerned about behaviour management in informal settings; something Tofield et al. (2003) reported is often a problem in practice. Finally, the factor which exacerbated the problem of including informal science education with formal programmes is the issue of procedural and financial challenges (Chesebrough, 1994; David & Matthews, 1995). It seems schools may be reluctant to allow visits because of financial costs and safety procedures, especially in the case of field trips.

2.2.6 Section Summary

There are three forms of learning, formal, non-formal and informal. Formal learning adopts traditional educational approaches, comprises compulsory schooling, and being involuntary, teacher-centred and assessment driven. Non-formal learning is voluntary and allows for some choice, while informal learning is totally voluntary and highly learner-centred. Research suggests that informal science education offers a supportive component to formal preservice teacher education such as the providing for opportunities to repeat lessons multiple times, employ small student-teacher ratios which helps in building better student management skills, and allows these teachers to gain autonomy and make decisions. The collaborative learning culture at ISIs helps make science content gains. Since ISIs have a range of resources they facilitate self-directed learning, and teachers have opportunities to experience constructivism and its implications in teaching science which helps broaden their epistemologies. However, there are inherent challenges such as the unique nature of the context, time spent at ISI, support when these teachers return to formal classrooms, and financial and procedural limitations. Section 2.3, which follows, discusses the characteristics of these Informal Science Institutions (ISIs) in more detail.

2.3 Informal Science Institutions (ISIs)

While science is mainly taught in a classroom and/or in a school laboratory, students can also learn science outside school. Much of the science they learn in these environments comes from relatively informal experiences. These include having conversations, watching and listening. These informal learning sites are referred to as ISIs, and range from having formal and structured lessons to entirely informal and *ad hoc* experiences. Section 2.2, noted ways students engage at these ISIs which has implications for learning in science classrooms. This section will explore learning experiences at ISIs. Also, there is discussion on the characteristics and importance of including *free choice learning* when visiting ISIs. Some of the roles of ISI facilitators will also be discussed, with emphasis on student learning at ISIs. Section 2.3.1, which follows, discusses learning which occurs at these ISIs.

2.3.1 Learning in Informal Science Institutions

There is a body of research in investigating learning in ISIs (Aubusson, Griffin & Kearney, 2012; Dillon, 2012; Dillon, Rickinson, Teamey, Morris, Choi & Saunders, 2006; Falk & Dierking, 2000, 2012; Tal, 2012; Tal & Morag, 2007, 2009). There are many types of ISIs, botanic gardens, museums, field study and industrial sites that are of particular interest because they are well researched as ISIs (Rennie, 2007; Rennie & McClafferty, 1995; 1996; Tal, 2012; Tal & Morag, 2007, 2009). ISIs are perceived as places where people "construct personal meaning, have genuine choice, encounter challenging tasks, take control over their learning, collaborate with others and feel positive about their efforts" (Paris, Yambor & Packard, 1998, p. 271).

As noted in Section 2.1, the social constructivist position focuses our attention on the social processes operating in these ISIs where students construct their knowledge through collaborative learning. Lave and Wenger (1991) view learning as social practices rather than just cognitive processes, and Rogoff sees learning as occurring through participation (Rogoff, 1991, 1995). These sociocultural perspectives consider learning as a situated activity occurring through *participation*, as *distributed cognition*, and as *mediated action* and ISIs provides opportunities for such learning practices. This perspective on learning is reinforced by studies conducted at say a museum where 'meaning making' occurs through visitor conversation within a social context (Abu-Shumays & Leinhardt, 2002; Leinhardt, Crowley, Knutson, 2004).

The literature suggests that personal identities are influenced during visits to ISIs. Griffin (2007) and Leinhardt and Gregg (2002) found that this 'learning talk' can comprise up to 89% of the total time spent in student conversations at ISIs. In support of this, many studies suggest that students value autonomy and independence with their learning at ISIs because they have the opportunity to investigate their topic and become accustomed to new learning contexts. An example here is interactional exhibits in museums allow fun learning to occur and act as stimulus for later and more detailed learning (Rennie, 2007). It seems that students view their learning at ISIs as entwined with the social environment, and studying in small groups provides an optimal context for sharing information and finding answers to complex issues (Falk & Dierking, 2000; Paris, 1997). According to Griffin (2004) students enjoy learning and engaging in socially mediated learning environments where they have both *choice* and *control* of what they are doing. Bamberger and Tal (2007) unpacked this perspective, and reported that even limited choice helps students to develop natural curiosity with substantial engagement and sound learning outcomes.

Despite ISIs being useful learning environments, the literature indicates that not all encounters lead to valuable learning outcomes. Work by Kisiel (2003a) and De Witt (2007) suggests that lack of preparation and planning on the part of the teacher as well as choosing poor activity types, leads to limited use of LEOS. However, learning science can often be intrinsically self-motivating, emotionally satisfying and personally rewarding when students are given the opportunity to clearly understand what and why they are learning, choose a particular topic and ways to learn, and to see value and use for what they are learning. Student intrinsic motivation it seems is heightened and deeper learning is more likely to occur (Campbell & Tytler, 2007; Dierking, Falk, Rennie, Anderson, & Ellenbogen, 2003; Griffin & Symington, 1997; Falk, 2006) under such circumstances.

As noted above, ISIs have huge potential for informal learning, where student learning is self-paced and self-directed. Below is a summary of factors that are reported to engage student learning at ISIs (Griffin & Symington, 1997):

- Dealing with things/ideas that are real, important and relevant to them;
- Manipulating and exploring real things and phenomena;
- Dealing with ideas that have meaning for them;
- Working with others, talking and sharing ideas;
- Participating in learning based on their real experiences;
- Working with the teacher and not for the teacher;
- Given opportunities to take ownership of what and how they are learning; and
- Finding their own real answers.

Given the importance of including informal learning into formal science lessons, some of the characteristics and importance of *free choice learning* are discussed in Section 2.3.2.

2.3.2 Free Choice Learning

Since 2001, free choice learning is a term widely associated with visits to ISIs. Free choice learning is defined as voluntary, student-centred and totally driven by personal, sociocultural and physical contexts. Free choice is one of the characteristics of informal learning and comparison made to an iceberg: "Mostly invisible at the surface and immense in its mostly submerged informal aspects" Livingstone (1999, p. 49).

Free choice learning places importance on both the physical and social contexts of learning. It is important that the learner perceives that reasonable and desirable learning choices are available so that there is the possibility for freedom to select or not to select to learn (Dierking & Griffin, 2001; Falk, 2001a, 2001b; Falk & Dierking, 2000; Falk, Storksdieck & Dierking, 2007; Rennie & McClafferty, 1996). To illustrate, visits to ISIs with family members are very different in terms of free choice compared with those organised by schools, where the teacher controls students, seeks to maintain good behaviour and to meet certain learning goals. Research indicates that even on school visits students and teachers both appreciate some degree of choice, and students are reported to have better learning outcomes when given some degree of choice (Falk & Dierking, 2000; Rennie & McClafferty, 1995, 1996).

The literature thus suggests that inclusion of degrees of choice in learning, from free choice, to limited choice, to no choice, can influence student learning at ISIs. The notion of free choice in learning was expanded by Tunnicliffe, Lucas and Osborne (1997) who argue that these types of practices (especially at the zoos and museums) are missed opportunities because the visits are not structured enough, neither focused on specific learning outcomes, nor employ pedagogies that encourage students to do thoughtful work. However, it seems that subsequent discussion between the teacher and students followed by reflections may lead to learning.

Other studies reported that more meaningful learning was associated with limited choice patterns that allowed the students to explore an exhibit with *some* support and guidance, and where support was provided by the learning task and was related to the visit theme (Bamberger & Tal, 2007; Jarvis & Pell, 2005). The literature suggests that activities with limited choice served as mediation tools that scaffold student learning. For example, Jarvis and Pell (2005) report that limited free choice was found to be more effective in exploring space exhibits in a national space centre in the UK where students explored exhibits using a long list of their own questions. However, the literature also suggests that teachers who take students for LEOS are most often concerned about managing student behaviour, the learning tasks they have planned, worksheets they have to complete as well as keeping to the allocated time for the visit (Griffin, 2004; Griffin & Symington, 1997; Kisiel, 2003a, 2003b). This lack of choice is also exacerbated by the fact that ISI staff asks all the questions and rarely allow students any opportunities to make inquiries during these demonstrations (Bamberger & Tal, 2007).

Given what the literature says about LEOS and learning at ISIs, it seems that the nature of the visit largely determines the degree of choice, and this includes both the physical and social components of these ISIs. These circumstances range from specific characteristics of the institution and the constituents of the exhibit, presence and behaviour of ISI staff, and whether the activities are games and simulations or traditional worksheets, or meeting teachers' objectives. It seems different ISIs are similar with regard to provisions for learning. Another study on outdoor learning since the 1990s focused on geological field trips, and emphasised the importance of well-structured learning activities and careful preparation done in class prior for the visit. It seems that outdoor activities help students give meaning to abstract science ideas (Aubusson et al., 2012; Gardner, 1991; Orion & Hofstein, 1994). A key feature which affects students' choice has to do with the setting. The literature suggests that while museums and zoos are examples of 'safe' environments for free choice learning, field trips to wetlands and geological formation along canyon cliffs can be settings where students can get easily harmed if not constantly supervised, hence limiting the opportunities for free choice learning.

The literature thus indicates that there are a number of factors that influence student learning. These range from the ability to have freedom of choice in learning as mentioned above, the nature of the ISI such as zoo or museum, and the experience and behaviour of ISI staff. A zoo, for example, has living animals, which draws more attention and emotional engagement than museum exhibits. If ISI staff are younger, say graduate students as is often the case at zoos (see Tofield et al., 2003), they share their experiences more enthusiastically with visiting students. Similarly, younger students engaging in role-playing activities (e.g., being an astronaut during a visit to a space centre) involving ISI staff who explain what to do and take an active interest in the activity, has a positive impact on students' memory and attitude toward science (Jarvis & Pell, 2005; Tunnicliffe, Lucas & Osborne, 1997).

Finally, it seems that teacher preparation and objectives for LEOS at ISIs strongly influence the degree of choice in learning. Rennie and McClafferty (1996) argue that LEOS should be used to *complement* classroom teaching and they say teachers should integrate visits with their teaching programme. However, some research suggests that during LEOS, there is a need for balance in student interactions, with each other, and with the exhibits (Cox-Petersen et al., 2005; Rennie & McClafferty, 1995; Tal & Morag, 2007). However, while one might assume that a zoo, for example, is a likely setting for free choice learning, Tofield et al. (2003), say that even though the constituents of the environment are free choice in nature, activities may still be highly teacher centred, and transmissive in nature which reduces students choices about their learning.

In summary, while at least some freedom of choice in learning makes LEOS beneficial, there are other factors which are no less important. To what extent of choice and control determines the meaningfulness of LEOS is difficult to determine, but having limited choice with some structure and guidance tends to have positive effect upon students learning of science. Given the importance of ISI staff in influencing students learning of science, their varied roles are discussed next in Section 2.3.3.

2.3.3 Informal Science Institution Facilitators

The role of ISI staff or facilitators varies, depending on the nature of the ISI and the individual. ISI staff create a scaffold between the visitors and the exhibits by engaging in conversation with audiences about the complex topics presented in exhibits. They serve as the human interface, and provide a direct link between the visitors and exhibit (Gupta & Adams, 2012). Across different ISIs, facilitators have different titles and varied levels of responsibility. Some tasks include interacting with visitors in the exhibit gallery, conducting demonstrations, facilitating experimental activities, leading workshops and developing activities for school-groups. ISI staffs are faced with diverse visitors on a daily basis, and they need adequate training in order to have active engagements. They need training in diverse teaching approaches if they are to move away from transmitting information to audiences, to engaging in inquiry experiences. Training can develop a disposition in ISI staff to become teachers or educators (Gupta & Adams, 2012). Hence, an ISI is also a possible site for teacher education as it allows aspiring teachers to practice teaching through actively engaging with diverse audiences in science activities. Indeed, many ISI staff members are ex-teachers or have completed teacher education programmes (Tofield et al., 2003). With access to a variety of science-rich experiences, ISIs are rich learning 'laboratories' for future teachers as suggested in Section 2.2.4.

Given the importance of informal learning at ISIs, there is a need to include the teaching of these skills in preservice teacher education programmes. The literature suggests that ISIs provide opportunities for these types of teaching and learning which should be taken advantage of. Learning to teach is a practical activity and in order to learn how to teach, one has to actively engage in the activity of teaching (Adams, 2007; Tobin & Roth, 2006). While learning can happen across different contexts (Bruner, 1996), learning that happens in one context can influence learning and action that happens in another context. The knowledge and skills that are developed at these ISIs can influence one's ability to teach in formal classroom contexts. The literature also suggests that preservice teachers who received substantial professional development had the potential of developing skills and dispositions that were more reflective of a free choice learning environment (McGinnis et al., 2012; Gupta & Adams, 2012). When ISI staff feel successful during interactions with visitors, they make multiple attempts, each time adjusting their interactions to meet diverse learner needs, hence developing better skills at engaging. These types of interactions provide excellent opportunities for both, professional development and preservice teacher education (see Section 2.2.4). Section 2.3.4, explores to what extent students' learn at ISIs.

2.3.4 Student Learning at ISIs

Student learning at ISIs is an excellent way to enrich students learning experiences, motivate them to learn science, encourage lifelong learning and also expose them to future careers (Bamberger & Tal, 2007; Hofstein & Rosenfeld, 1996; Tal, 2012). Since these informal settings are idiosyncratic, learning occurring at these sites depends on the students' personal and social context in which learning takes place (Rennie & Johnston, 2007). There are four reported learning outcomes of ISI visits Braund & Reiss (2006):

- Improved development and integration of scientific concepts;
- Social outcomes such as collaborative work and responsibility of learning;
- Access to non-school material and 'big' science; and
- Improving attitude to school science and stimulating further learning.

Falk and Dierking (2000) stress the point that learning at ISIs is a slow process and say it is largely dependent upon the student's prior experiences and knowledge. Consistent with this, in the last two decades some authors have concluded LEOS has not seen to be contributing towards conceptual learning of science (see e.g., Rennie & McClafferty, 1996) for a variety of reasons that are now discussed.

First, improved development and integration of science concepts is an important learning outcome of LEOS. Meaningful learning can occur in such rich physical and social environments (Ash & Wells, 2006) and this is mediated by use of objects, symbols and people (e.g., ISI staff, parents and teachers), a central idea championed by Vygotsky (1986). Vygotsky's idea of Zone of Proximal Development (ZPD) is particularly helpful for understanding learning that occurs at ISIs where the environments are characterised by mediation provided by objects. Social outcomes such as collaborative work and responsibility of learning are other outcomes of learning that occur at ISIs. This collaborative knowledge building, mediated by dialogues and artefacts, provide students with opportunities to seek answers for their inquiries instead of striving for predetermined answers.

Additionally, access to non-school material and 'big science' is a key facet of learning opportunities at ISIs. Learning is associated with the physical characteristics of the learning environment and is also enhanced by social interactions among students as noted above. Such sites allow students to negotiate meaning and find answers to complex questions (Ash & Wells, 2006). ISIs allow students to engage in dialogues with each other and with ISI staff in multiple ways, and also provide a variety of opportunities for sensory experiences (Ash, 2002) that helps students to develop a better understanding of the science taught in the classrooms and relate this to experiences around them.

Furthermore, learning at ISIs helps improve attitude to school science and stimulates further learning. Recent reviews of literature about school fieldtrips, for example, suggests that affective outcomes such as increased motivation, interest, and improved attitude towards the topic might have a greater long-term cognitive impact than factual knowledge that tends to disappear over a short period of time (Bamberger & Tal, 2007; De Witt & Storksdieck, 2008). Nundy (1999) argued that interactions of both affective and social interactions enhance the overall learning, going on to say that high-order thinking capabilities are enhanced through challenges such as group work, talk, control of learning, thinking and talking about learning.

The literature suggests that whilst learning opportunities at ISIs may result in enhanced learning outcomes, there are a number of factors which limit this. If LEOS is not prepared for properly, than there are possibilities of losing good students from science and the very essence of school science can become questionable by decision makers (Dori & Tal, 2000; Tal, 2012). This means those students who have the potential of doing well in science will not be encouraged to pursue this path, because they become disenchanted with the way science ideas were presented to them. While a comprehensive review by Rickinson et al (2004) reported that out-door learning contributes to a positive, cognitive, affective and social impacts, they go on to note that this is probably purely because such learning is strongly linked with pedagogies which promote active learning, self-control, real-world experiences, group work and inquiry. So such learning may more naturally lead to more interactive pedagogies that are the root cause of improved learning rather than the outdoor experience per se.

As alluded to above, student learning at ISIs is different from that which occurs in classrooms. It is less structured, less sequential, it occurs in a short period of time, it is influenced by physical factors and allows more interactions between students and between students and ISI staff. This leads to a further limitation or difficulty, assessing student learning in these environments. The literature suggests that simple pre- and post-test approaches that, in effect; assume a single experience for all students is not adequate (Rennie & McClafferty, 1996). An alternative is to use open-ended questions about what the students have learnt, because this addresses both cognitive and noncognitive outcomes. However, a limitation here is the difficulty to assess the depth of learning. Finally, a cross-curricular approach, such as including environmental (Dillon, 2012), health, social and citizenship issues (Grace & Ratcliffe, 2002) where several learning outcomes achieved provide a better understanding of the experiences students encounter during LEOS (Tal, 2012).

2.3.5 Section Summary

Learning at ISIs is different from that in a classroom, and to maximise such opportunities, there is a need for defined objectives and the use of appropriate pedagogies. The tasks designed to facilitate learning during LEOS should allow for scaffolding of students' prior experience and knowledge, have structure but some freedom of choice, should be student-centred and include task-centred activities. It is important to take full advantage of LEOS and provide opportunities for students to socially, emotionally and cognitively interact with others and artefacts to promote (lifelong) learning. Although the idea of free choice learning is appealing, research shows that meaningful learning is associated with limited choice that allow students to explore the exhibit with some support and guidance, and learning tasks should be related to the visit theme. The roles of ISI staff to make learning more meaningful to a diverse group of students are important. The type of learning which occurs at ISIs involves cognitive, affective and social aspects with multiple interrelated outcomes. Given the importance of context, Section 2.4, next discusses the characteristics of out-of-school learning in more detail.

2.4 Out-of-School Learning

Informal and non-formal learning, outdoor learning, and free choice learning all are terms used to describe the variety of out-of-school learning opportunities that are provided at various ISIs. In this section, the focus will be on LEOS, ways in which LEOS are facilitated, learning environments and LEOS, and implications for school science. Section 2.4.1 which follow discusses learning experiences outside school.

2.4.1 Learning Experiences Outside School (LEOS)

By using a neutral term like LEOS, a variety of ISIs can be examined, along with other outdoor activities such as the study of estuaries, streams and mangrove ecosystems (Dillon, 2012; Dillon & Scott, 2002; Osborne & Dillon, 2008; Rennie, Feher, Dierking & Falk, 2003; Tal, 2012). Therefore, this will be the term used throughout this thesis. A report by the UK Government (2006) argues that educational visits and LEOS can bring learning to life by deepening students' understanding of the environment, history and culture, and improving their personal development. This, it is claimed, could be achieved if learning outside the school becomes the heart of every school's curriculum and ethos. Science curricula are seen as the vehicle of instruction for topical issues such as health and environment. Hence, this belief leads to the notion that LEOS could potentially provide opportunities that reflect real life learning processes (Dillon, 2012; Dillon & Scott, 2002, Osborne & Dillon, 2008).

LEOS could be conducted either locally where students go on fieldtrips, as well as making cultural visits overseas. An example of a fieldtrip where children can gain valuable learning experiences is when school grounds are used imaginatively. For example, ecological succession of plants could be learnt by students digging a piece of land in their school ground and recording observation of different plant growth over a period, instead of only using textbooks as a teaching resource. These types of activities would allow learning through social construction of knowledge, consistent with social constructivist theories of learning as described in Section 2.1.3.

Rickinson, et al (2004) together with Orion and Hofstein (1994) concluded from examination of some 150 research reports on out-of-school learning published between 1993 and 2003, that there was substantial evidence to indicate LEOS properly conceived, adequately planned and taught well, and effectively followed up, offers students opportunities to develop their understanding and skills in ways that add value to their everyday experiences in the classroom. It was also noted that LEOS can have a positive impact on long term memory due to the memorable nature of the experiences at ISIs, forming a basis for reflection as well as deepening their understanding (Farmer, Knapp & Benton, 2007; Gostev & Weiss, 2007; Whittington, 2006). However, Rickinson et al. (2004) also noted that despite substantial evidence for the efficacy of LEOS, in some parts of the world, LEOS is severely restricted, particularly for science. This is apparently due to concerns such as fear of litigation, cost, or lack of teacher education.

A number of authors have recognised that the value of LEOS is allowing and encouraging collaborative learning (e.g., Dillon, 2012; Farmer, Knapp & Benton, 2007; Gostev & Weiss, 2007; Leinhardt & Crowley, 2002; Rickinson et al., 2004; Rogoff & Lave, 1984; Whittington, 2006). The literature also suggests that context is integral to what we learn, saying that knowledge is a product of the context in which it is learned (Rogoff & Lave, 1984; Solomon, 1983). If school knowledge is to be made meaningful to students, there should then be a link between school science and the real world that can be achieved by providing learning experiences outside school.

There are two types of LEOS reported in the literature: One where the teacher leads the visit (Lucas, 2000; Tal, 2012; Tal & Morag, 2007), and another where the visit is guided and facilitated by ISI staff, such as an education officer or guide (Cox-Peterson et al., 2003; Tal & Morag, 2007; Tofield et al., 2003). In both situations, the teacher is typically responsible for providing learning or curriculum objectives, and this may include conceptual learning, enrichment, social and emotional engagement, improving attitude to science, changing pace, and reinforcement for certain content or merely to have fun (Bamberger & Tal, 2007; Falk & Dierking, 2000; Rennie & McClafferty, 1995, 1996). As noted above, one of the most common objectives for LEOS is to increase motivation, interest and attitude which consequently results in greater long-term cognitive impact than factual knowledge that can 'disappear' after a short time. However, if such objectives are to be achieved, then teachers need to prepare students for these learning experiences (DeWitt & Storksdieck; 2008; Gilbert & Priest, 1997; Hein, 1998). Section 2.4.2 which is next, discusses ways in which LEOS are facilitated.

2.4.2 Ways in Which LEOS are Facilitated

The literature reports a number of ways by which LEOS can be facilitated. This includes the diverse roles of teachers ranging from active mediation between the ISI and the school, planning and monitoring student behaviour. ISI staff as well as the nature of these ISIs strongly influences student learning during LEOS. One of the ways strongly recommended in the literature is for teachers to *integrate* visits to ISIs with their teaching programmes and use LEOS to *complement not replace*, learning activities in classroom. The key to deriving the most from LEOS is when learning is facilitated by pre-planning and post-visit activities all linked directly to curriculum objectives (Patrick, Mathews & Tunnicliffe, 2011; Rennie & McClafferty, 1995; Tofield et al., 2003), which help give meaning to abstract science ideas studied in the class (Anderson et al., 2000; Bolstad, 2001; Orion & Hofstein, 1994). A good example is when students are introduced to study the topic 'ecology'. It is important that they are introduced to certain terms and definitions before the LEOS (Biggs, 1999; Goodrum, 2007; Preston & Rooy, 2007), and should be required to report back their findings in class upon their return to help enhance their learning of the topic.

Some authors argue that lack of integration of field-based experience with students own prior experiences during planning means students are rarely engaged in small group activities during LEOS (Tal, 2012; Morag & Tal, 2009). Skilful and thoughtful educators are sensitive to the learning needs of children, and adjust their facilitation to maximise the development of independent learning that is self-regulated, personally meaningful and motivated. These teachers look for personal 'hooks' for learning when planning for LEOS (Emmons, 1997; Waite, 2011), ensuring constant communication with ISI staff when planning the trip jointly. An example is when teachers draw upon students experiences and knowledge of local fish, breeding conditions, and diseases when planning for LEOS in marine studies.

The nature of the site to be visited also has a profound effect on student learning during LEOS as mentioned in Section 2.3.2. It was reported that ISIs should also be thoroughly explored by teachers before a trip is planned to help facilitate LEOS. It seems more meaningful learning occurs in some settings because of intrinsic interest (Ballantyne & Packer, 2002; Tunnicliffe, Lucas & Osborne, 1997). Comparing zoos and natural history museums, it was noted that live animals drew more attention from students. Another cohort of studies conducted in nature centres in Australia found that student engagement was limited by the distance they had to travel, amount of walking involved, highly structured learning activities and fear of creatures. However, it was also reported that students enjoyed being given the choice of what to do during excursion, opportunity to learn outside the classroom, learning together with friends, seeing something new and being able to touch plants and animals (Ballantyne & Packer, 2002; Tunnicliffe, Lucas & Osborne, 1997).

The literature also reports that teacher modelling is important in positively influencing students. One way of achieving this is by relating concepts learned during LEOS to students own experience. For example, research conducted in a wild life sanctuary in Belize which included a variety of activities such as hiking, night walks, group discussions, and lecture by a guest speaker, indicated that teacher modelling strongly influenced the engagement of students during LEOS (Emmons, 1997; Morag & Tal, 2009; Ratcliffe & Grace, 2003).

Unfortunately, with the exception of a few studies that report exemplary work, the literature indicates that most teachers fail to provide proper preparation for their students, and poorly plan these learning activities (Griffin, 1994; Griffin and Symington, 1997; Jarvis & Pell, 2005; Oulton, Day, Dillon & Grace, 2004; Tofield et al., 2003; Weelie & Wals, 2002). Research suggests that teachers often just use worksheets to keep students busy recording what they observed and this does not take maximum advantage of the trip (Griffin, 1994; Griffin & Symington, 1997; Jarvis & Pell, 2005). The literature also notes that teacher preparation ranges from well-defined to undefined plans. Some teachers are noted to employ informal strategies to encourage more engagement of leaners at ISIs (Kisiel, 2006a, 2006b; Tofield et al., 2003). Kisiel (2006a) reported that probing students understanding through questioning helped find answers to questions and also assisted students to learn collaboratively. There is also evidence to suggest that besides teacher preparation, another factor which helps facilitate LEOS is ISI staff experience, and disposition which can impact on students' learning experience. It seems ISI staff typically use lectures, worksheets, scientific jargon, have limited discussions with students and also use simple recall type questions (if any) to make inquiries to clarify student understanding (Cox-Petersen et al., 2003; Tal & Morag, 2007; Tofield et al., 2003). Often, these explanations do not address student's prior knowledge and experience (Schauble, Gleason, Lehrer, Bartlett, Petrosino, Allen, 2002). Whilst ISI staff members reportedly enjoy the challenge of helping students, inadequate use of appropriate pedagogies does not help maximise the depth of learning.

However, well planned activities by ISI staff can have a positive effect on student learning, but only if integrated with pre- and post-visit planning by the teacher. As an example, museum worksheets designed to promote and scaffold learning, improve students' on-task behaviour and encourage curriculum related conversations (Mortensen & Smart, 2007; Tal & Morag, 2009). When this happens, it seems that balancing freedom of choice and scaffolding students learning, results in meaningful learning outcomes. A review of recent studies indicated better attempts by ISI staff to address learning theories in general and the literature on learning in museums in particular (Anderson, Bethan & Mayer-Smith, 2006; Mortensen & Smart, 2007; Tal & Morag, 2009; Tran, 2007). Analysis of task sheets used by experienced ISI staff revealed that they were quite different from the traditional worksheets and were designed to promote scaffolding of learning, as well as increase curriculum conversations that affected students' on-task behaviour (Bamberger & Tal, 2007; Morag & Tal, 2009; Mortensen & Smart, 2007; Tran, 2007).

In summary, there are a number of ways of facilitating LEOS. Teacher-led LEOS requires learning to be facilitated by pre-planning and post-visit activities all linked directly to curriculum objectives which helps give meaning to abstract science ideas studied in the class as well as choosing ISIs that are more stimulating and engaging. The LEOS led by ISI staff should promote and scaffold learning, improve student's on-task behaviour and encourage curriculum related conversations by eliciting student prior experiences. Section 2.4.3 discusses student learning styles and their learning environment.

2.4.3 Learning Environment and LEOS

Learning environments is a highly topical and active area of research in science education (Doran, Fraser, & Giddings, 1995; Fraser, 1991, 1994, 1995; Fraser & Fisher, 1983a, 1983b; Fraser, Giddings, & McRobbie, 1992, 1995; Huang & Fraser, 2009). The term *learning environment* refers to the social, physical, psychological and pedagogical context in which learning occurs, and which affects student achievement and attitudes (Fraser, 1991, 1998, 2012; Goh, Young & Fraser, 1995; Teh & Fraser, 1994; Wong & Fraser, 1996). Numerous studies suggest that student perceptions account for a significant variation in learning outcomes, and this is not related to their personal background. This implies that student learning outcomes can be improved by creating environments conducive to learning. The literature indicates that the learning environment strongly influences students' achievements of certain outcomes which are enhanced if the classroom environment is changed to one which is closer to that preferred by students (Aldridge & Fraser, 2008; Aldridge, Fraser & Ntili, 2009; Fisher & Fraser, 1983; Fraser & McRobbie, 1995; Handelzalts, van den Berg, van Slochteren & Verdonschot, 2007; Moos, 1974).

Learning environments provided by ISIs such as museums and science centers can contribute greatly to the understanding of science, and encourage students to further their interests outside school. Inclusion of topical issues such as health, environment, social and citizenship issues might motivate more students to appreciate the value of science and to consider studying it for longer (Dillon, 2012; Dillon & Scott, 2002).

Besides learning science in the classroom, LEOS provides diversity in environment in which learning takes places. This helps encourage students to see science as a human activity rather than abstract knowledge and so has the potential of integrating formal learning in the classroom with informal learning that occurs outside school (Dillon, 2012; Dillon & Scott, 2002; Osborne & Dillon, 2008). The opportunities for science learning beyond the classroom continues to grow in terms of number and sophistication, and research also continues to show the potential benefits that can accrue (Dillon, 2012; Dillon et al., 2006). If students enjoy science more through seeing it in a wider context, and develop an appreciation that science is a human activity, they will start seeing science as more relevant and appealing rather than just as an abstract knowledge (Ballantyne & Packer, 2002; Emmons, 1997; Gough, 2002; Morag & Tal, 2009). Since LEOS is seen to allow active learning which affects students overall enjoyment and learning outcomes, Section 2.4.4 next discusses its implications for school science.

2.4.4 LEOS: Implications for School Science

LEOS is associated with high levels of motivation underpinned by attributes of choice about what one wants to find out and to do with, so with a clear sense of purpose. This type of learning opportunities helps develop new ways of thinking, interpreting, analysing information, which in turn leads to the development of scientific skills. In contrast, the classroom based curriculum may be limited by less sophisticated resources, constrained by fixed-step curricula and restrictive teaching strategies (Griffin & Aubusson, 2007; Hsi, 2007). This incongruence between students' formal and informal learning environment necessitates the need to explore natural learning processes that operate during LEOS and the need to relook at the ways science is taught and learnt in schools.

School science needs to take more into account of students' out-of-school science learning experiences and develop greater consistency to synthesise learning across formal and informal domains (Aubusson, Griffin, Kearney, 2012; Coll, et al, 2013; Rennie & McClafferty, 1995, 1996). ISIs typically do offer features to guide teachers to develop new teaching strategies, especially strategies that focus on active learning (see McGinnins, et al, 2012; Osborne & Dillon, 2008). Active learning requires a change in both how science teaching is done in classrooms as well as the role of teachers in facilitating learning. Science learning tasks need to enable rich conversations that extend beyond formal school settings. This would involve design and mediation of school-based projects utilising new literacies, collaboration and creativity which resonate with student experiences and as noted earlier and LEOS provides us with an opportunity to do this.

As noted above, students' informal participation in digital space is altering their social identities, style of learning and patterns of communication (Coll, et al, 2013; Green & Hannon, 2007; Facer, Furlong, Furlong & Sutherland, 2003; McFarlane &

Sakellariou, 2002). The large scale availability of the Internet as a learning environment for non-formal and informal learning has changed rapidly and dramatically. The use of digital media for interaction has become, in a short time, a normal daily activity and many students cannot imagine the world without digital media. The literature recommends the use and promotion of the Internet to produce and publish work, critique and analyse important topics where students exchange ideas and learn as a community. These social spaces enable collaboration and conversation among students, where they share ideas with and question each other, the teacher and other experts. However, central to this type of learning is autonomy and independent learning which would require high levels of support if students are to flourish in intellectually challenging science learning environments (Aubusson & Griffin, 2008; Warschauer, 2007). Further emphasis is placed on the key role of teachers in these collaborative project-based science tasks, in modelling and mentoring to support self-directed processes, especially with students who require learning support. Students need teachers' support to help understand the broader context of their school science experiences and also for developing skills for appraising evidence, recognising social and other influences and implications for decision making (Osborne & Hennessy, 2003; Warschauer, 2007).

While consideration for learning at ISIs such as museum and zoos, digital space, and through science research and display events such as science fairs can help generate high levels of engagement, enjoyment with patterns of deep involvement and commitment, these features are equally capable of failing young students (Aubusson et al., 2012). However, when they succeed, a set of characteristics of participation that becomes evident includes: autonomy, interactions with other peers, artefacts, parental and teacher support, and a creative display of communication in their social spaces. While these features may not easily be accommodated in school science lessons that involve acquisition of a multitude of prescribed science content, concepts and abstractions, they can provide a platform for building generic capabilities such as new literacies, project management, team work and communication skills.

2.4.5 Section Summary

The growing body of research on LEOS suggests that visits to ISIs can enhance science learning. Because LEOS can be voluntary and learner driven, it provides opportunities for integrating formal learning in the classroom and informal learning outside schools and mediating learning with the use of digital technologies. This could help generate high levels of engagement and enjoyment with patterns of deep involvement and commitment which results in intrinsic rewards from these activities and a deeper level of understanding in science. Section 2.5, which follow, provide the Chapter summary.

2.5 Chapter Summary

The literature suggests that there are three main theories of learning, namely, behaviourist or traditional, constructivist, and sociocultural, each of which includes social processes operating in a learning environment and thereby influences student learning. Likewise three types of learning identified were, formal, non-formal and informal; with an emphasis on informal learning through visits to ISI and using digital technologies for collaboration. A number of benefits were identified for including informal learning at ISI for preservice teacher programme, and it appears that ISIs provide rich learning environment by stimulating curiosity and exploration to ensure positive learning outcomes. The choice of ISI, teacher support and preparation as well as the roles of ISI staff can influence the effectiveness of LEOS.

Finally, the literature suggests that LEOS is an important part of the educational landscape, and properly facilitated in a given learning environment has the potential to support school science.

The next chapter discusses the literature on some new teaching strategies, technology-enriched learning environments, development of teacher professional skills, and some suggestions on future directions of ways we can enhance LEOS and integrate with classroom learning.

CHAPTER THREE
LITERATURE REVIEW:
THEORETICAL PERSPECTIVES FOR THE INQUIRY

Overview of the Chapter

As noted in Chapter 2, the literature suggests that LEOS properly facilitated has the potential to stimulate curiosity among students and contribute to some learning outcomes. But it was argued that in order to support and explore these collaborations, there is need for the use of support such as using digital technologies through which we might stimulate learning in a variety of ways and develop a constructivist or learner-centered learning environment. This chapter thus comprises a review of relevant studies investigating ways of enhancing students' science learning experiences outside school using digital technologies. Section 3.1 discusses technology-enriched learning environments; Section 3.2 explores literature about the learning design and emerging technologies, and Section 3.3 considers New Media Literacies (NML), exploring their potential to transform learning. The chapter concludes with Section 3.4, which discusses the use of learning management systems (LMS) such as Moodle in science teaching and learning, and considers how LMS can be integrated in LEOS.

3.1 Technology-Enriched Learning Environments

The focus in today's science classrooms is finding ways to improve teaching and enhance learning through a variety of tools. There is a growing body of literature on the value of inclusion of digital technologies in science classrooms, since students can enjoy some autonomy in these new digital spaces and take an active role in choosing what, where, how and with whom they learn without time and curriculum constraints. This chapter begins with a discussion on science learning in the digital world, followed by discussion on what students are learning in these 'digital playgrounds'. The social context for ICT use is considered and the section concludes by considering informal learning in new digital spaces, where students learn autonomously. Next, Section 3.1.1 discusses science learning in the digital world.

3.1.1 Learning Science: A Digital Experience

According to the literature there is a growing need to recognize the range of digital experiences students have outside school. Students learn through experiences, encounter cognitive conflict, and engage in social interactions during their informal use of the digital spaces. This section discusses the different types of digital technologies and considers how they are being used by students today. Also there is discussion on reported advantages and concerns associated with the use of these digital technologies.

The literature describes information and communication technology (ICT) as a general term that emphasizes the integration of telecommunication, computers, software, and audiovisual systems to enable users to create, access, store, transmit, and manipulate information including the use of Internet (Dhingra, 2003; Nakhleh & Krajcik, 1994; Stevenson, 1997). The terms 'Web' and 'Internet' in this chapter as well as in the literature, are used interchangeably. The literature suggests that the growth of computer ownership and access to ever more diverse webpages has been virtually exponential in recent years (Chandra & Fisher, 2009; Coll et al, 2013; Gerber, Cavallo & Marek, 2001; Ryoo & Linn, 2012). Web-based learning in particular is popular; this is a form of e-learning, broadly inclusive of all forms of educational technology, such as playing of video games, using mobile phone technologies, chat rooms, whiteboards, avatars, the Web, and digital television. The literature goes on to say that there a several *advantages* of using digital technologies.

Firstly, the Internet is used extensively by students as a learning environment in both non-formal and informal learning settings (Gerber et al., 2001; Zandvliet, 2012). Given the availability of information on the Internet, it has for many people including students become the first 'port of call' when seeking information. Teachers often now pose questions that require students to use the Internet to access that information through application rather than simply recall it. These activities necessitate the development of transferable skills, which in essence are the skills needed to adapt and apply the knowledge and skills to changing situations (Murray-Rust, Rzepa, Tyrrell & Zhang, 2004; Sasson & Dori, 2012). The literature suggests that popular websites such as *YouTube* are very commonly accessed and these enable the individual to upload materials, which may be of interest to others as well as comment on materials already present on the site. These are sources of both entertainment and for interaction among students, and provide for interaction between students, teachers and experts. More interactive sites such as those with web-based video games enable the user to interact with the programme, but typically only to a limited and predefined extent (Coll et al., 2013; Ryoo & Linn, 2012). However, teachers are reportedly using web-based programs to challenge students and help them engage in more active learning. For example, Van Rens et al (2010) developed an inquiry-based chemistry module at the secondary school level, and this involved students working in teams to use the Internet for sources of information, and who subsequently interacted in an Internet 'symposium' involving peer review of their reports with classes in other places, and the students eventually published their results on the Internet.

Secondly, research on ICT use in education suggests that its use helps motivate students to learn (Limnious, Roberts & Papadopoulos, 2008; Rodrigues, 2010). This motivational impact on students' learning helps afford ownership and control with respect to pace and choice of content (see also Ryoo, & Linn, 2012; Van Rens et al, 2010). Examination of children's digital technology use, be it computer games players, Web use or especially mobile phone technologies, suggest these users demonstrate significant commitment to these activities, and it seems that learning is predicated on a high degree of motivation (Harkin 2003). This is not just the obvious kind of engagement that one might expect students to show in matters that they were interested in, but a particular focus on an emotional kind of involvement in the use of ICT. This has been described by researchers as students using ICT-based activities as part of the construction of their own personal identity (Facer et al., 2003; Livingstone, 2003; Turkle, 1995) in which learning to use the technology is not simply a process of acquiring useful skills, but strongly embedded in the young person's immediate social world and is thereby instrumental for these individuals in maintaining and constructing a sense of self.

Thirdly, research also suggests that interactivity between simulations, avatars created by the user and whiteboards, strengthens the case for student empowerment. These types of learning's afford the user some measure of personalized learning (Lim, 2008; Rebolledo-Mendez, Burden & de Freitas, 2008). The literature further states that new technologies have had an impact on science education, and this has often been related to the use of ICT as cognitive tools for students (Jonasson, 1994; Vygotsky, 1978). What this means is that these technologies led to changes in the ways science has been taught in school, and the 'tools' include science lectures, science discussions and collaborations, data collection and representations, science visualizations and science simulations and modeling (Chandra & Fisher, 2009; Coll et al., 2013; Liber, 2005; Linn, 2003; Tao, 2004). Some suggestions for teachers to make effective use of ICT are summarized by Osborne and Hennessy (2003) as:

- Ensuring that ICT use is appropriate and adds value to learning activities;
- Building on teachers existing practice and on students' prior knowledge;
- Structuring activity while offering students responsibility, choice and opportunities for active learning;
- Prompting students to think about new concepts and relationships, to participate in discussions, to analyze critically data and information, and to focus on research tasks;
- Linking ICT use to ongoing teaching and learning activities; and
- Encouraging students to share their ideas and findings.

However, while there are a number of reported benefits as noted above, digital technologies such as the Web, also have a number of concerns reported in the literature. It is not the tool itself that affords the new forms of participation as listed in Table 3.2 in Section 3.3, but rather *how the tools are employed* by specific users in specific contexts. Some researchers report that factors which impede learning chemistry are where animations and simulations are involved (Azevedo, 2004; Eilks, Witteck & Pietzner, 2009; Huk, 2007; Schwartz, Anderson, Hong, Howard & McGee, 2004). Misleading visualizations found on Internet, may for instance develop inadequate competencies, limit ability of recognizing spatial relationships properly, and result in inaccurate learning of scientific concepts.

An example would be the animation of kinetic theory of particle where the liquid particles have spaces between them (Harrison & Coll, 2008). It seems, not surprisingly, that the role of teachers is integral when it comes to effective use of web-based learning (Cope, Kalantzis & Lankshear, 2005). Teachers are responsible for creating learning opportunities as well as finding ways for other participants (students and other staff) to engage and even change these activity structures (DeGennaro & Brown, 2009). Teachers thus need to be very careful in selecting things like visualizations from the Internet and make sure that they are appropriate for the intended learning goals. The teacher should be reflective if designing visualizations by him or herself.

Other reports in the literature suggest digital technologies can be used as a tool for inquiry like activities, but it seems that this may restrict rather than promote inquiry (Waight & Abd-El-Khalick, 2007). Apparently the presence of computers may mean group activities became more structured with focus on sharing tasks and individual accountability, rather than spending time on meaning making and collaborative group discourse. Also, teachers need to be familiar with the specific tools and the software, and also appreciate the pedagogical value of ICT. They need to know, for example, how the technology could help the students' link the work done in say a laboratory session to the understanding of scientific concepts (Cope et al, 2005; DeGennaro & Brown, 2009).

In summary, the literature suggests that digital technologies have become an integral part of student's recreational life and it would be foolish not to consider these experiences when planning science lessons. While there is a range of e-learning platforms used by students outside school, it is important to note its significance in students' social learning culture. While the literature on the integration of ICT in classrooms reports advantages for students' such as increased motivation and empowerment, and also personalizing learning, there are reported factors which also could impede learning. Hence, technologies like other teaching innovations require careful planning and appropriate pedagogy if they are to be effective. Given its importance, Section 3.1.2, discusses what students are learning in these digital playgrounds.

3.1.2 Students in Digital Playgrounds

This part of the literature review concentrates on the use of digital technologies, which potentially offer a more ‘interactive’ relationship between users (particularly those which facilitate community) or between user and text. The literature suggests that students’ informal participation in these new digital spaces is altering their social identities, styles of learning and patterns of communication (Facer et al, 2003; Green & Hannon, 2007). ICT integrated learning in science helps enhance new literacy skills, creativity, social skills and digital competencies (Lewin, 2004; Walsh, 2007).

These new literacy skills incorporate the ability to make use of images, photos, videos, animation, music, sounds, texts and typography all leading to the development of confidence in new modes of inquiry and literacy as well as becoming literate in digital formats for expression (Crook, 2008; Warschauer, 2007). Pioneering research in gaming communities, for example, shows positive links with new identity formation and science literacy development (Gee, 2003; Squire, 2007). This identity formation included the development of collaborative skills, decision-making, negotiation and resource management skills, self-monitoring skills, team based problem solving and systematic thinking.

There is a body of literature documenting research on the wide range of affordances for the use of ICT in science education as shown in Table 3.2. The four main effects of ICT used specifically in science teaching are; promoting cognitive acceleration, enabling a wider range of experience, increasing student self-management and facilitating data collection and presentation (Dori, Rodrigues & Schanze, 2013; Webb, 2005). Some factors reported to help enhance the effective use of ICT during science teaching are duration, instruction, use of instructional support to facilitate learning and the types of scientific concepts being portrayed (Hegarty, 2004; Tversky, Morrison, & Betrancourt, 2002) as well as teacher knowledge of concepts, processes and skills in a subject area (Webb, 2005).

An analysis of literature on the use of ICT shows that there is a significant body of work reporting on the potential of ICT integrated learning in science in the area of *computer visualization and modeling*, and the literature reports that this tool has significantly improved spatial visualization skills in students (Hansen, Barnett, MaKinster & Keating, 2004; Piburn, Reynolds, McAuliffe, Leedy, Birk & Johnson, 2005). Studies on dynamic visualization using web-based programmes suggest these help improve students' conceptual understanding of abstract scientific phenomena such as photosynthesis and chemical reactions (Cook, 2006; Fleming, Hart & Savage, 2000; Kelly & Jones, 2007; Rotbain, Marbach-Ad & Stavy, 2006; Williamson & Abraham, 1995). Indeed, several studies suggest that dynamic visualizations are more effective than static illustrations in helping students develop a coherent understanding of abstract concepts such as molecular changes and developing a stronger mental model of molecular processes (Ardac & Akaygun, 2005; Ryoo & Linn, 2010; Yarden & Yarden, 2010). When using dynamic visualization, while low achievers might suffer from the presence of redundant illustrations, researchers say that when illustrations are carefully designed and integrated in high quality learning materials, students with low prior knowledge benefit the most (Barak & Dori, 2011; Mayer & Gallini, 1990). Interestingly, while the literature described above suggests that dynamic visualization is superior to static illustrations in terms of developing spatial skills, there are other findings which report the opposite (Höffler & Leutner, 2007; Tversky et al, 2002). It is reported that despite the potential benefits of dynamic visualization, these tools are not always more effective than static illustrations (Höffler & Leutner, 2007; Kali & Linn, 2008; Lowe, 2003; Mayer, Hegarty, Mayer & Campbell, 2005; Tversky et al., 2002). However, it seems that by using both forms of learning, teachers are able to provide for differing learner needs. The literature thus warns us that it is not the tool itself that affords these new forms of participation, but rather how the tool is employed by specific users in a specific context (Cope et al, 2005; DeGennaro & Brown, 2009). For example, when teaching about enzyme activity using web-based learning, it is important to also provide the student with some literature on why the enzyme remains unchanged as well as use real life examples. This means the way the teachers decide to use the tool to create learning opportunities, as well as the various ways students choose to take up or engage with and even change these activity structures influences the learning outcomes.

Another reason for including ICT in teaching is the visualization capability that allows teachers and students alike to present and view chemical phenomena and processes via multiple representations (Dori & Kaberman, 2012; Slotta & Linn, 2009). The *WISE Science* (Web-Based Inquiry Science Environment) is an example of a program which offers such an approach. Here teachers incorporate inquiry projects during instruction in a variety of ways. Typically, students engage in projects in pairs so that they can collaborate and build on one another's ideas. Using the WISE inquiry map, students interact with one another at their own pace, with the ability to revise or return to previous parts of the projects and strengthen explanations, drawings, and models during the project (Dori et al, 2013; Slotta & Linn, 2009). Teachers not only take opportunity to have small group discussions, but use of these technologies helps teachers see real time progress and responses of students within the project. From these visualizations, teachers are then able to identify quickly which students have not understood a concept and then provide targeted help.

Digital technologies in classrooms also are reported to help strengthen graphing, high order thinking, experimental processes and problem solving skills (Adams & Shrum, 1990; Dori & Sasson, 2008; Krajcik, Mamlok & Hug, 2001; Rodrigues, 2010). For example, utilization of computers in science laboratories linked to sensors and data loggers 'releases' students from mundane data collection tasks and allows more time for them to focus on problem solving and generation of knowledge while employing high order thinking skills (Adams & Shrum, 1990; Dori & Sasson, 2008; Krajcik, Mamlok & Hug, 2001). Graphic technology can also be used to develop deeper understanding of science concepts by linking phenomena with graphic representations.

Another use of digital technology reported in the literature is integrating blogging into daily classroom practice (Davis, 2006; Leuhmann & Frink, 2012). The findings from research reported in the literature indicates that students take up such practices with considerable 'fervor'; posting warnings, reminders, elaborate graphs and diagrams, sharing jokes as well as registering apologies for imperfections (Davies, 2006; Leuhmann & Frink, 2012; Robertson, 2008). Although students may show initial skepticism about blogging, they soon describe dependence on the use of blogs for understanding the course content and participation in class. It also is reported that blogging helps develop a sense of community and shared ownership in learning

(Davies, 2006; Leuhmann & Frink, 2012). Blogging thus is reported to help develop classrooms which transform how students engage with concepts and participate in meaning making. Related to this is the use of *wiki*. Interactive sites like *wiki* engage students in a highly interactive manner, and, for example, the use of *wiki* during field based learning is reported to allow students and their teaching mentors assume additional roles meaning students invest more time and effort in the organization of an investigation of the relationship between different science content (Davies, 2006; Robertson, 2008).

Another of the many applications of digital technologies reportedly used in science learning is the utilization of animated visuals (Eilks et al, 2009; Mayer & Chandler, 2001). The literature says that animated visuals are used in attempts to help students make links between the macroscopic, submicroscopic, and symbolic representations used in science. An advantage reported is that such visuals helps demonstrate the dynamic nature of particle activity at submicroscopic level, something not easily achieved in classroom teaching (Eilks at el., 2009; Mayer & Chandler, 2001). Yang, Greenbowe and Andre (2004) suggested that animated visuals help reduce the emergence of misconceptions related to basic chemical principles where an example would be studying dynamic equilibrium in a closed system. However, the literature also alerts to some issues with regard to the use of animated visuals (Huk, 2007; Mayer & Chandler, 2001; Ploetzner, Bodemer & Neudert, 2008; Rodrigues & Gvozdenko, 2011). While some researchers have argued that the high transfer rate of information could limit student's attention span, others report challenges with the students' spatial relations. For example, when studying photosynthesis, the reactions appear to be too quick displaying many reactions at once, requiring students to link the processes which can be difficult, but it also helps students to understand why light is necessary for photo-excitation, which releases electrons to participate in other cellular reactions.

In summary, students use their 'digital playground' in a variety of ways in order to make sense of scientific concepts. These ways include learning through dynamic visualizations to foster conceptual learning, using ICT as a pedagogical approach in inquiry based learning, strengthening graphing, and problem-solving skills, and using blogging/*forum* and *wiki* along with animated visuals. It seems then that students increasingly engage in the use of digital technologies in everyday life and in learning. Use of digital technologies in learning, however, occurs within a particular social context. Section 3.1.3, next discusses the social context for ICT use.

3.1.3 Learning Environment: The Social Context for ICT Use

This section examines the role played by students in the models of learning which emerge from studies of the social use of ICT, and the ways in which these models overlap with contemporary trends in learning theory, in particular social constructivism. The literature reports that the ‘psycho-social learning environment’ influence or determine learning in classrooms (Cuban, 2001; Fraser, 1986, 1991, 1994 & 1998; Fraser & Walberg, 1991; Khoo & Fraser, 2008; Tao, 2004; Zandvliet & Fraser, 2004a, 2004b; Zandvliet & Straker, 2001). Today’s classrooms are experiencing an ever increasing demand for computers and diversification in their use, which could be due to overwhelming increase in technological and societal pressures. Due to these demands, there is a need for evaluation of these technology-rich learning environments, as well as a closer integration of educational technologies, curriculum and instructions.

These conceptual models of learning environment consist of three overlapping sphere; *ecosphere, sociosphere and technosphere* (Gardiner, 1989; Moar & Fraser, 1996; Zandvliet & Fraser, 2004a, 2004b). In this model, the *ecosphere* represents a person’s physical environment and surrounding, which includes equipment and network configurations. The *sociosphere* includes an individual’s net interactions with other people within that environment and how these interactions are closely associated with learning and other outcomes. The *technosphere* includes all person-made things and this includes the actual use of ICT based on the teaching strategies and lesson objectives. However, it is important to broaden the discussion to include the social context (sociosphere) of student in order to investigate effects of ICT in science classrooms (Cuban, 2001; Fraser, 1998; Sandholz & Reilly, 2004; Zandvliet, 2006, 2012).

The uses of ICT have indeed had an impact in the area of science communication and collaboration between students and between students and teacher (Jonasson, 1994;

Linn, 2003; Piburn et al, 2005; Tao, 2004). As mentioned earlier, to maximize the use of ICT in student's sociosphere, there is a need to increase technological access and equally to integrate its use within classroom practice. Increasing the number of computers, for example, does not necessarily imply a change in the instructional methods and/or improved learning (Cuban, 2001; Linn, 2003; Sandholz & Reilly, 2004; Zandvliet, 2006). The literature suggests that there is an expectation from schools that teachers must be technical experts and this often works against quality classroom instruction (Becker & Ravitz, 2001; Sandholz & Reilly, 2004; Zandvliet, 2006). Here, the literature notes that teachers often feel frustrated when they are required to spend time on technical issues rather than instructional ones. Additionally, in order to use ICT as an integrated medium of instruction, teachers first have to up-skill themselves in technical skills, and it seems this requirement often reduces its use or leads some teachers to abandon its use entirely. The literature then says that although the need for adequate training and support for teaching staff is well documented, professional development for technology often are lacking (Becker & Ravitz, 2001; Webb, 2005; Zandvliet, 2012).

The literature suggests that using multimedia instructional modules as part of their sociosphere, results in an improvement in cognitive development (even though the improvement ranges widely) when fostering science collaboration (Hansen et al, 2004; Piburn et al., 2005; Tao, 2004). Rich qualitative data on interactions between students indicate that they engage in co-construction of knowledge during these activities and that the learning environment is comprised of both, the ICT software as well as teacher during these social interactions. For example, teachers could check every step of an organic synthesis in chemistry to make sure that the correct reactants are chosen to form the intended products. While there is a range of affordances of ICT in science education, some studies suggest that their use can restrict rather than promote interactive learning (Waight & Abd-El-Khalick, 2007). It seems that the views and perceptions of teachers and students in relation to specific learning environments moderate the effectiveness of any technology in meeting stated or expected learning outcomes. In order to plan and select appropriate practices, teachers need to understand the relationship between the affordances of ICT resources, their own knowledge, and processes and skills in the subject area, hence the need for evaluating learning environment when using ICT (Webb, 2005).

The literature reports on validated new learning environment instruments which have been used to explore how technology-rich learning environments can be structured and how positive educational outcomes can be achieved (Dorman, Aldridge & Fraser, 2006; Falloon, 2006; Khine & Fisher, 2003; Logan, Krump & Rennie, 2006; Walker & Fraser, 2005). These studies observed that technology-rich settings include having a number of networked computers, with general availability of Internet access for students and their substantial use in delivery of curriculum. The rationale for technology use is that the intent of ICT was to support constructivist reform minded ideas about teaching and learning. The themes which emerged from analysis of these findings revealed an increase in student motivation and self-autonomy. According to Tobin (1993), the use of both quantitative and qualitative methods enables researchers to view the learning environments from different perspectives. For example, the qualitative analysis would highlight certain themes of the learning environment while the quantitative data will either further reinforce this or display a different perspective.

What Is Happening In this Class (WIHIC) questionnaire, for example, was used to describe the social context for ICT usage. This instrument proved to be a highly reliable and valid instrument in other studies (Fraser, 1981; Liu & Zandvliet, 2009; Zandvliet & Buker, 2003), and analysis of the results obtained from student questionnaire data yielded an important perspective on the learning environment in ICT-rich settings. Although there was variability in ratings, overall students perceived most aspects of their learning environments to be positive and characterised them as being higher in terms of student cohesiveness, cooperation and task orientation, than other scales such as involvement. Interestingly, autonomy/independence had the lowest score of the five learning environment scale, indicating a negative perception of this factor in contrast with other work (see e.g., Liu & Zandvliet, 2009; Zandvliet, 2012). Studies in Malaysia in ICT-rich setting learning environments and in Canada and Australia revealed that students perception of autonomy/independence also was rated as negative relative to other learning environment measures (Zandvliet & bin Man, 2003; Zandvliet & Buker, 2003). This negative rating is particularly problematic since educators saw this as a key goal for the implementation of ICT in learning.

In summary, it appears that the psycho-social classroom environment in ICT-rich settings can influence student learning outcomes positively. While studies using WIHIC mentioned above revealed a positive change in student cohesiveness, cooperation and task orientation, there was a notable negative score on autonomy/independence across different countries. These findings imply that there is a need for a closer integration of educational technologies, curriculum and instruction and more research is needed in this area. Section 3.1.4 which follows discusses informal learning in these new digitally-enriched learning environments.

3.1.4 Informal Learning in a Digital Playground

This review is an attempt to understand how students may be learning with ICTs in a range of settings outside the school, especially in contexts not traditionally associated with education. One of the aims of this review is to make the case that learning in out-of-school settings needs to be accorded status and understanding as we seek to enhance the education system more generally (Dillon, 2012; Dillon & Scott, 2002; Kelly, 2000; Osborne & Dillon, 2008; Rennie, 2007). Informal learning is used here to mean learning that happens in a different way from that in schools, in a different place, about different things, or anything learnt that is not currently valued by our education system. The second ranges from formal settings (schools) through intermediate kinds of learning spaces (like museums and galleries) right through to social structures we do not tend to think of as learning organisations (like families or friendship groups). At the same time, we need to recognise the growing number of digital experiences that may be explored across a range of different settings through the mediation of the Web; from online chat rooms and multiplayer games communities as mentioned in Section 3.1.1 above (Gerber et al, 2001; Griffin & Symington, 1997; Lyman et al, 2005; Rennie, 2007).

The first grouping might consist of those experiences organised specifically to support formal educational achievement but accessed in informal conditions. At home, for example, many children encounter digital resources designed specifically to support the school curriculum, whether through commercial educational resources or through publicly funded websites such as the BBC revision websites (Lomas, Burke & Page, 2008; Siemens, 2005).

The second grouping might consist of those activities which adopt informal approaches to learning formally sanctioned knowledge; in other words, resources which encourage engagement with socially-valued information and resources through non-curriculum linked formats. The UK Government's investment in *Culture Online*, for example, is seeking to extend the reach of the UKs cultural institutions through the development of a resource aimed at creating 'virtual' museum experiences.

The third grouping is of students' use of digital resources that are primarily viewed as leisure activities and which, often, are viewed by the formal education sector as being of little educational value. This comprises, for example, students' playing of computer games, their use of chat rooms, and their use of digital media such as digital television. What this means is that activities such as those listed above are now mediated by digital technologies as a normal part of students' social and cultural lives.

The literature presents a mixed picture of the effects of ICT-rich learning environments on student learning outcomes. As noted above, quantitative studies using learning environment questionnaires like the WIHIC, suggest that the integration of ICT into classroom practice does not foster autonomy and independence in learning; the opposite of what was expected. However, qualitative work provides a more positive picture on ICT integrated classroom learning environments (see e.g., Lomas et al., 2008). Qualitative reports indicate that digital spaces allow rich conversations where the users share differing points of views and engage in experiences which do give them autonomy. Students are reported to actively participate in tasks done digitally, giving them a voice and a strong sense of audience as the students explore, interact and share their thoughts and ideas in authentic ways. These gives rise to common interests and networks and knowledge can be built, collaboratively (Siemens, 2005). Examination of literature on informal learning in digital spaces suggests that even tasks designed to involve self-direction and autonomy often require peer mentoring (Lewin, 2004; Scanlon et al, 2005; Willett, 2007; Zandvliet, 2012). The literature further goes on to say that the tasks are designed to allow for collaborative learning. These can be mobile in nature, and are often situated in learning networks and communities such as accessing Moodle site for *forum* discussions to catch up on work which the student may have missed since he/she was sick and away from school. These tasks usually require problem solving and inquiry based learning skills which can be better done in a collaborative learning environment. Peer mentoring and modeling are distinctive characteristics of these informal e-learning experiences. There is a strong emphasis on self-directedness meaning that a crucial role is to be played by more knowledgeable friends, siblings and other adults (Gerber et al., 2001; Green & Hannon, 2007). The tools present in these digital spaces gives users an enhanced ability for peer dialogues, asking questions and guidance. An example of this approach is students' use of chat rooms. Willet and Sefton-Green (2003) say these digital spaces are places in which new models of learning are occurring and where students are given opportunities to explore new ways of communicating. For example, girls 'playfully' take risks, experimenting and negotiating meaning as they engage in discourses. Far from acting as passive learners in these digital spaces, students come to assert control and agency online, using the virtual experience as a means of cementing peer group relationships.

These kinds of studies also show how ICT experiences function as 'learning cultures'. They do this in a number of ways. Young girls, for example, are able to be inducted into the peer world and, by drawing on quite formalised teaching and learning roles in their talk, becoming much more flexible and demanding students in their social leisure cultures than might be expected (Crook, 2008; Facer et al., 2003; Green & Hannon, 2007; Lewin, 2004; Walsh, 2007). Like the studies of computer games, this facility to adopt teaching and learning roles in play contrasts with what we might expect from children, and shows how they have taken such pedagogic structures from school into informal use.

Another key area of interest in children's cultures is the ways in which students' social agency may be transformed by access to new technologies (Katz, 2000; Lewis 2002). What this means is that as the computer makes no concession to age, the occupations and opportunities traditionally seen as an 'adult domain' are now open to those students with access to the new technologies. Lewis's (2002) study of young entrepreneurs, or Katz's (2000) portraits of young 'geeks', emphasised how students are interacting with adults as their social equals.

It seems, however, that digital spaces are capable of failing students as well as helping them develop a collaborative learning culture. When they succeed, a set of characteristics of participation becomes evident, such as autonomy, peer support, teacher and parental support, and tasks which allow problem solving and inquiry based learning.

3.1.5 Section Summary

The central argument of this section has been to make the case that new and different kinds of informal learning are occurring outside of the formal education system and that there needs to be a culture shift to accommodate insights from research in this area within the formal sector. However, the key to understanding informal learning is to fully acknowledge the necessary movement across, between and through the sites and kinds of learning available to students today. This section argues that in their leisure, at play and in the home with their friends, students can find in ICT powerful, challenging and different ways of learning. The emphasis is on sharing, working together, and using a wide range of cultural references and knowledge to provide a collaborative learning culture. Next Section 3.2 discusses digital learning environments.

3.2 Digital Learning Environments

Recently, effort has been focused on designing learning environments that engage students in ways that emulate the activities of a practicing scientist. An integral aspect of this includes the use of various technologies to support processes used by scientists to perform an inquiry, collect and analyse data and share their findings. The last decade has therefore seen the introduction of many emerging technologies into classrooms. These include visualisations, animations and simulations, to name a few. Each of these tools provides an insight into learning designs that actively immerse students in roles which reflect those of scientists (DeGennaro, 2012; Gomez, Fishman & Pea, 1998). For example, computer-based modelling and simulation allows students to build their own models by identifying relevant factors and variables and hypothesising relationships, all of which helps in developing an understanding of modelling as a process in science investigation as well as developing understanding of science ideas (Bliss & Orgborn, 1993; Brodie, Gilbert, Hollins, Raper, Robson & Webb, 1994; Mellar, Bliss, Orgborn & Tompsett, 1994).

These new evolving designs alter the roles of teachers and students (Cox & Webb, 2004; Linn & Hsi, 2000; McLoughlin & Oliver, 1999; Mellar et al, 1994; Shulman, 1987; Somekh & Davies, 1991). Hence, this section begins with a description of some of these emerging technologies and their associations with learning designs such as *Collaborative Visualisation* (CoVis), *Computer Supported Intentional Learning Environments* (CSILE) and *Kids as Global Scientists* (KGS). Following this, there is discussion on research trends in learning environments and ways of encouraging collaboration and knowledge building among students. This is followed by discussion on co-constructing scientific processes in a technology-mediated learning environment. The last part of this section considers research findings on student interaction and immersion with the new design and learning experiences. Section 3.2.1, which follows, discusses evolving learning designs.

3.2.1 Evolving Learning Designs: Drawing From the Learning Sciences

The learning sciences are dedicated to research and development of pedagogical, technological and social policy innovation (DeGennaro, 2012; Rodrigues, 2010). The aim of researchers in this field is to study the design, implementation and evolution of designed learning environments, with a goal of improving learning science. Learning design is an area of research which has recently gained recognition in developing technology to support the learning of science. The learning scientists' commitment of examining how technologies supports science learning comes to some degree from the realisation that professions today are technology dominated. For example, professions such as scientists, doctors and teachers, find their work entails interpreting and accessing multiple forms and representations of information in the form of visualisations, texts, numbers, images and other graphical forms.

There is a growing demand for schools to produce a citizen with 21st century capabilities. Among these 21st century capabilities, the ability to create knowledge is paramount. Knowledge creation has traditionally been framed in terms of individual creativity, but recent literature places more emphasis on social dynamics (e.g., Brown & Duguid, 2000; Csikszentmihalyi, 1999; Sawyer, 2007). Content knowledge, it is argued, is not isolated; rather it is seen as embedded in pedagogical models such as problem-based-learning, cooperative learning, and real-world contexts. Having students become active agents in knowledge construction is an important theme in the learning sciences literature (Engle & Conant, 2002; Herrenkohl & Guerra, 1998; Lamon, Secules, Petrosino, Hackett, Bransford, & Goldman, 1996; Lehrer, Carpenter, Schauble, & Putz, 2000; Paavola & Hakkarainen, 2005; Scardamalia & Bereiter, 1994; Tabak & Baumgartner, 2004). One of the commonly promoted practices, inquiry-based learning, arguably comes closest to supporting the needs of a modern environment which places the students in the centre of scientific practices. For example, students' employment of creativity, innovation, critical thinking, problem solving, communication and collaboration is intertwined in these learning designs. These skills are fostered as students create research questions, develop theories, use and offer reliable explanations, and make accurate predictions. In carefully crafted learning designs, students also engage in an iterative process of building theories, asking questions, investigating, reasoning, and predicting (American Association for the Advancement of Science, 1993; National Research Council, 1996). In learning environments that incorporate learning design, students work closely and interactively with others to inform their thinking. For example, students might post findings about astronomical cycles and describe how they affect seasons on earth, and this could be checked and critiqued by other students.

The other projected outcome for new learning designs is to allow students to utilize technology as part of their learning process and as a result, gain numerous technology-related skills. For example, students may learn how to phrase focus questions, seek evidence on claims and learn collaboratively through online discussions. The partnership for 21st century learning summarises this as the development of information literacy, which is afforded via information and communication technologies. These emerging technologies have been reported to become an interconnected part of student learning (Hickey & Whitehouse, 2010; Jane, Fleer & Gipps, 2010; Rodrigues, 2010; Sawyer, 2006).

In order to inform the design of the learning environment, with the goal of improving education, learning scientists have developed new research frameworks and methods to examine the multi-dimensional view of learning with a particular emphasis on technology to support the learning of science (Barab, 2006; Bielaczyc, 2006; Cobb, Confrey, diSessa, Lehrer & Schauble, 2003). The analysis is focussed on an orchestration of, and relationship between, expected tasks, encouraged discourses, established norms, used tools and materials across multiple contexts. The research involves the voice and involvement of all participants connected to the learning environment including teachers, students, researchers and designers. However, a criticism of these new learning designs is the absence of beliefs about learning and knowledge, learning activities and participant structures, configurations of both physical and virtual spaces (Bielaczyc, 2006). Therefore it is critical to examine, not only the learning design outcomes, but the social and technical aspects of the learning design. The technosphere and sociosphere described in Section 3.1 thus act together to create the 'learning structure' (Coakes, 2002; Trist & Bamforth, 1951). The sociosphere comprises of students' interactions with a wide range of software both outside of the formal, 'taught' classrooms as well as during formal lessons. Specifically, when students acquire knowledge in the context of a goal-orientated activity as in the case of a group inquiry project, they are more likely to use that knowledge later. Similarly, in collaborative learning, distributed expertise and multiple perspectives, enable students to accomplish tasks and develop understanding beyond what they could achieve alone.

Furthermore, the collaboration requires students to express beliefs in ways that serve to organise what they know and to identify gaps in their own understanding. Therefore, students need new learning environments that allow them to learn through collaborative, open-ended activity, even as they are becoming proficient at understanding the concepts being studied. The learning designs have to consider these experiences where students use digital technologies and create emerging technologies which help transform learning. Section 3.2.2 discusses learning environments and ways of encouraging collaboration and knowledge building among students.

3.2.2 Collaboration and Knowledge Building

As mentioned in Section 3.2.1, technologies have supported scientific collaboration and knowledge building for many years. Collaborative learning has been embedded in the work of scientists where they connect with each other through the Internet for sharing knowledge and expertise. These connections have been crucial for scientific progress, especially for complex investigations where more than one area of expertise is required. On this basis, educational designers have taken advantage of the flexibility and connectability of electronic mediums to allow students to learn in ways which are similar to a scientist. Today, *Web 2.0 Technologies* makes knowledge construction and building easier. This Section discusses three evolving designs namely CoVis, CSILE and KGS, and considers how these collaborative software packages are reported to afford the organisation and sharing of information to support collaboration and knowledge building.

Affordances is a term coined by Gibson (1979) and used both in human computer interaction field (Gaver, 1991; Norman, 1988, 2002) and the education literature (Downes, 2002; Kennewell, 2001; Laurillard, Stratford, Luckin, Plowman & Taylor, 2000) to describe opportunities provided for users in ICT-based learning environments. McGrenere and Ho (2000), working in the context of software design, identified resources such as teachers, parents, scientists (telementors) and other student's which they argue add to the affordances provided by the ICT. The collaborative software called Collaborative Notebook (DeGennaro, 2012; Edelson, Pea & Gomez, 1996; Gomez, et al., 1998) was modelled loosely on the notion of a scientist's notebook. This notebook was developed as part of the CoVis project, a research and development testbed for project activities in high school Earth and environmental science classrooms.

This software was designed to support collaborative learning models, where students worked with team members to post questions, share databases with team members, and have access to remote mentors (called telementors). The idea was that this software assisted students to both collaborate with each other as well as with real scientists (O'Neill, Wagner & Gomez, 1996). The literature also suggests that this software model was an accessible design to support iterative practices such as giving students opportunities to post, refine and quickly receive feedback on the on-going scientific inquiry (DeGennaro, 2012; Edelson et al., 1996). Additionally, the software provided a much shorter feedback cycle between work performed by students and guidance from the teacher than is ordinarily possible in a pencil and paper environment. The teachers could monitor students work more closely and help guide their efforts earlier and less dramatically. This effective integration encompasses the opportunities for distributed knowledge through technical supports of the discussion posts, databases and remote access (Edelson et al., 1996; Gomez et al., 1998; Webb, 2005).

A second example of innovative software is CSILE, which draws on Internet connectivity. This is a web-based tool designed for students to interact with each other across a communal database. This online database has both text and graphic capabilities, which allows it to be used as both a collaborative as well as problem-based learning tool. The design of this software draws upon the knowledge building environment philosophy, which is grounded in the belief that discourse is a primary part of science learning (Scardamalia & Bereiter, 2006). A review of education studies about the use of CSILE suggests that learning through communal collaboration using CSILE databases yields common understanding and expands the base of accepted facts by that community (Lave & Wenger, 1991; Scardamalia & Bereiter, 1993, 1994, 2006). The CSILEs multi-window networked learning environment affords students the opportunities to work across various resources such as computer tools, textual and graphic resources, peers and teachers, in order to build an understanding of scientific concepts. Students work in teams, receive guidance from teachers, access scientific content and socially construct knowledge. A key success of knowledge building in platforms like CSILE is accessing multiple forms of information with and through the technology, where students become a legitimate part of building knowledge together (Lave & Wenger, 1991; Scardamalia & Bereiter, 2006).

The third collaborative model which uses the affordances of the Internet is KGS. The literature reports that this learning design is similar to CSILE, and that both allow students-negotiated conversations, which helps foster their own knowledge of the concepts under discussions (Brown & Campione, 1994; DeGennaro, 2012). This design allows for inquiry-based learning between individuals who are geographically spread (such as teachers, other students, and parents) to view the same data. For example, if students are investigating weather and climate concepts in a city, all students could use the same weather data from the Internet, along with archival weather data to develop questions around the effects and impacts of weather in their hometowns and across the world. This software allows students to engage in an on-going process of using technology to link up with scientists in order to develop better understanding of science topics. This sort of technology-enhanced learning design allows for a collective practice of developing scientific process where students hypothesise, design experiments, argue theories and test solutions (Sandoval & Reiser, 2004; DeGennaro, 2012). Section 3.2.3 discusses co-constructing scientific processes for learning.

3.2.3 Co-construction of Knowledge

As scientists constantly strive to form an understanding of the real-world phenomena, they are typically immersed in a cyclical practice, which involves the use of technology and shared expertise as described above. This cyclical practice as discussed in Section 3.2.2 involves hypothesising, theorising, and testing solutions which forms the basis of co-constructing scientific process of learning. This section discusses three different learning models, namely, Explanation Constructor (EC), Scaffolded Knowledge Integration (SKI), and Learning by Design (LBD), all of which employ scientific processes in co-constructing knowledge.

The learning design software called Biology Guided Learning Environment (BGuILE) utilizes an inquiry-based learning model to involve students in a scientific 'mystery' (DeGennaro, 2012; Sandoval & Reiser, 2004). For example, students are presented with the facts that a certain number of finches have died in the Galapagos Islands during a drought which is an inquiry involving popular genetics. The students are required to solve this problem through analysis of extensive data which has been collected by real genetic scientists. In this situation, the students are using their technical and social spaces to assess and confer with peers to make inferences. The tool utilizes a model called Explanation Constructor (EC) where students employ the process of scientifically and socially constructing knowledge. That means that this tool helps them to scaffold their argument-making skills. However, while some researchers say that this model helps guide students to ensure that they are engaged in real-world scientific problem solving process, others are rather sceptical. These latter researchers say that a socio-technical system of learning like this will not by itself ensure the development of these scientific processing skills.

A review of studies conducted about the application of ICT in science learning and teaching, where for, example Bell and Bell (2003) reported that for the over 50 articles reported between 1993 and 2003, only a minority of the articles provided any evidence of effects on student achievement. The technology is then not itself central to the design, but rather an interconnected part of the learning environment where the teacher and their pedagogical approaches are crucial (Cox & Webb, 2004; Sandoval & Reiser, 2004; Tabak & Reiser, 1997). There is thus a need for balance between both virtual and face-to-face interactions. For example, work by Dori and Barak (2001) suggested that a combination of physical and virtual modelling supported the development of conceptual understanding of organic compounds. Simulations and animations also were reported to permit students to visualise structures and processes that cannot be observed easily (Barnea & Dori, 1999; Dori & Barak, 2001). These authors further suggested that different physical models emphasise different properties for example, molecule, and as students compare different models of the same molecule, they are able to integrate their understanding.

The Web-based Inquiry Science Environment (WISE) is a free online learning design, which offers numerous inquiry questions for teachers to choose from. Some of the topics listed are: genetically modified food, earthquake prediction and global warming. In this case, teachers choose an activity and guide students' through an inquiry process in order to take a 'position' on the problem. This learning design is based on a model called Scaffolded Knowledge Integration (SKI) which helps make thinking visible, provide social support, makes science accessible and promote autonomy in learning (Black & Wiliam, 2004; DeGennaro, 2012; William, 2008). In this model of learning, student engagement in questions at the beginning assists the teachers in elicitation of their prior knowledge. After students reflect on their current understanding, they immediately connect to the learning about, and responding to, a contemporary scientific controversy. WISE has embedded tools for providing organisational support for online investigation. These tools scaffold students' investigation, development of inquiry questions, note taking, evidence gathering, information sharing and knowledge display (DeGennaro, 2012; William, 2008). The difference between SKI and EC model is that the former allows for a more balanced combination of interaction between online and offline activities. Also, this immediate visibility affords teachers an opportunity to intervene immediately when misconceptions are noted as well as a need to enhance practice.

More recent studies of computer simulations, particularly of experiments, enable us to identify affordances, learning outcomes, and associated pedagogical practices which lead to conceptual change (Monaghan & Clement, 1999; Tao & Gunstone, 1999). The existence of alternative conceptions amoung students has been demonstrated many years ago and at all ages (Carey, 1985; Driver, Guesne & Tiberghien, 1985; Gilbert & Watts, 1983). For example, work by Tao and Gunstone (1999), 'Force and Motion micro-worlds' module was developed to help confront students' alternative conceptions. During the process, the students complemented and built on each other's ideas and incrementally reached shared understanding. Students' conversational interactions showed that this led to conceptual change.

Another innovation in science education, the CASE programme, also addresses aspects of scientific understanding that students find difficult to grasp through carefully designed tasks within a clearly defined pedagogy. The activities were based on the idea that the solution of problems, with carefully graded help (mostly through questioning) by a teacher or more able peer, leads not only to a solution of that problem but also to the general stimulation of the students cognitive processing mechanism (Adey, 1999; Vygotsky, 1986). The activities emphasise the importance of reflection, and of social exchange, in the development of thinking as well as the development of knowledge. Students who are encouraged to talk with the teacher or each other about how they are tackling and solving the problem, or what difficulties they are finding, become more conscious of their own thinking processes, and this metacognition promotes cognitive development as discussed in Section 2.1.3. For example, Huppert, Yaakobi and Lazarowitz (1998) used computer simulation to investigate students' ability to apply their knowledge to growth of micro-organisms.

The third example of a co-constructing process is evident in Learning by Design (LBD) (Kolodner, 1997; Schank, 1982). This model draws upon case-based reasoning to situate students in generating design skills, research skills, collaboration and record-keeping skills. LBD is designed to allow an iterative process of developing a hypothesis, designing and implementing an experiment. The expectation is that students learn by attempting to achieve design challenges. The design process promotes reflection on the experience needed to learn productively from this experience. This innovation is used to assist in the fostering and support of the learning process. In this programme, the students write their experiences into a Design Diary page, which later translates to an online case library for others to use. The Design Diary page scaffolds students by providing prompts as students create designs, run experiments and collect data. At designated points within the process, students share their data and data interpretations through poster presentations. In the process of planning, design, implementation, and redesign, students make changes based upon feedback from their presentations. Through working across technological supports and interactions with their classmates, students continuously create, revise and recreate their designs to work towards better solutions. Studies of LBD indicate that students rely on both technical and social activities to build understandings, apply what they learn, and get real-time feedback. In order to make maximum use of such learning models, students have to become immersed and interact in these e-learning environments. Section 3.2.4 which follows discusses interaction and immersion.

3.2.4 Interaction and Immersion in Digital Spaces

The current focus of much work in science education is establishing a good learning environment, in which students can take ownership of the questions they pursue, can design and implement an investigation to pursue their questions, and interpret and communicate their results to others (Linn, diSessa, Pea, & Songer, 1994). Having students become active agents in knowledge construction is an important theme in the learning sciences literature (see, e.g., Engle & Conant, 2002; Herrenkohl & Guerra, 1998; Lamon et al, 1996; Lehrer et al, 2000; Paavola & Hakkarainen, 2005; Scardamalia & Bereiter, 1994; Tabak & Baumgartner, 2004).

Of particular interest in this regard is collective cognitive responsibility, which requires students taking responsibility for the state of public knowledge (Scardamalia, 2002). It combines high levels of social and cognitive responsibility, engaging students in what knowledge-creating groups do in innovation-generating organizations (Bereiter & Scardamalia, 2006). This includes reviewing and understanding the state of knowledge in the broader world, generating and continually working with promising ideas (Scardamalia & Bereiter, 1993), providing and receiving constructive criticism (Sawyer, 2007), sharing and synthesizing multiple perspectives (Bielaczyc & Collins, 2006), anticipating and identifying challenges and solving problems (Leonard-Barton, 1995), and collectively defining knowledge goals as emergent of the process they are engaged in (Sawyer, 2007; Valsiner & Veer, 2000). Members take responsibility for sustained, collaborative knowledge advancement, collaborative learning, as well as personal growth. They connect their own interests and expertise with those of the community to achieve their individual and collective goals (Amar, 2002). To do this, educators have historically used models but more recently games are identified as acceptable activities which allow students opportunities to immerse themselves in virtual scenarios that replicate real world occurrences. Such games allow learning science as well as cultivating science skills and dispositions as mentioned above (Gee, 2003; Shaffer, Squire, Halverson & Gee, 2005; Squire, 2007). In the following discussion two specific types of games are discussed; namely, participatory simulations and Multi-User Virtual Environment space (MUVEs).

Simulations are one form of immersion that enhances students development of scientific knowledge (Meier, Reinhardt, Carter & Brooks, 2008; Rosenbaum, Klopfer & Perry, 2007). Participatory simulations are a set of role-playing activities designed to give students insight into the evolution of complex dynamic system. The intention of this learning design is to have students take up the different roles while making decisions or being part of the unfolding phenomena. The expectation is that the students will then gain a sense of influence of their role on the system. For example, students can become doctors, medical technicians and public health experts to understand infectious diseases. If students get the virtual disease, the immediate community aims towards the goal of interacting with other roles to find out how to make each other better. Attaining these self-developed learning goals and insights required and motivated students to understand the scientific principles involved. While the social and technical aspects of the design provide both immersion and affordances for learning, researchers found evidence of students' misconceptions also. It is important that teacher intervention help make explicit connections between activity and scientific understanding (Neulight, Kafai, Kao, Foley & Galas, 2007; Rosenbaum et al, 2007). Tools such as online chats or note books are means by which teachers can follow students' progress, assumptions and developing ideas. Hence, teachers could help identify misconceptions, and this help transform the learning tasks and cultivate scientific explanations.

Secondly, the MUVEs are a desirable space in which students participate in their leisure time. These are 3D spaces which immerses students in teaching and learning of science. Students can interact with each other and the digital artefacts of the learning environment through controlling avatars which are personal virtual representations. These avatars interact to act as cognitive scaffolds and assist with navigating problem sets. Students create rich narratives within their experiences which intern help develop scientific skills (Barab, Sadler, Heiselt & Hickey, 2007; Rosenbaum et al., 2007; Squire & Jan, 2007). The situated nature of learning helps students make ties between goals of activity and place (Lave & Wenger, 1991; Greeno, Collins & Resnick, 1997). Students also interact and access resources offline to win this game. This is a hybrid space where students can interact both in virtual games and in physical space structures, which provides them with the sensory experience that contributes to an authentic learning environment.

3.2.5 Section Summary

In summary, the literature discussed here focussed on interactions between students and new emerging technologies. Software packages such as Collaborative Notebook, CSILE and KGS and supporting paper-based materials were designed to provide affordances for the learning of concepts where students were known to experience inquiry-based learning opportunities. The learning models of co-constructing scientific processes such as EC, SKI and LBD helped demonstrate the importance of student-student interactions in many studies. There were benefits reportedly gained from increasing student collaboration and from increasing student autonomy, but the role of the teacher in facilitating the learning environment to promote collaborative learning and to scaffold students' learning is, as might be expected, crucial. As noted above, it is important that students immerse and interact with each other and with the software programmes in order to internalise the scientific events they learn through animations and or simulations. The process of meaning-making within social networks when using new emerging technologies gives rise to different types of literacies. Section 3.3, which follow, discusses these new media literacies.

3.3 New Media Literacies (NML) and Their Relevance in School Science Reform

The current focus of much work in science education reform is to bring more ambitious science learning into classrooms. Education reformers argue that students need to learn more rigorous scientific content than what is typically taught (AAAS, 1990; NRC, 1996). This means establishing a learning setting in which students can take ownership of the questions they pursue, can design and implement an investigation to pursue their questions, and interpret and communicate their results to others (Linn et al, 1994, MacBride & Leuhmann, 2008; Robertson, 2008; Webb, 2005). In order to learn scientific processes, students need to understand how the general strategies of science (controlling variables, hypothesising) are realized within particular scientific domains. Acquiring this understanding requires creating a classroom culture of inquiry which consists of communicating and establishing a culture that sets knowledge construction and the evaluation of knowledge claims in light of empirical evidence as the primary goals of classroom work (Brown & Campione, 1994; Crawford, Max & Krajcik, 1999; Duschl, 1990). The section begins with the historical definition of literacy and what constitutes new media literacies. Following this, there is discussion on research trends in NML and its potential for integration into teaching and learning. The last part of this section considers research findings on *Weblogging* (blogging) and *wiki* as participatory tools. Section 3.3.1, which follows, discusses literacy and new media literacies (NML).

3.3.1 Literacy and New Media Literacies (NML)

Literacy, prior to the 1970s, was a name given to programmes of non-formal instruction and in particular, in relation to adults who were deemed to be illiterate (Anderson, 1966; Freire, 1972, 1973; Freire & Macedo, 1987; Lankshear & Knobel, 2008). Within the formal educational setting, reading and writing were seen as essential tools for learning and as vehicles for accessing and communicating meanings via printed texts. Functional mastery of reading and writing was effectively taken for granted as bottom-line outcomes of classroom learning for all students other than those designated as intellectually impaired or as having severe learning disabilities. In any event, so far as curriculum and pedagogy within formal education was concerned, what was talked about, researched, debated and so on was not *literacy*, but rather *reading* and to a lesser extent *writing*.

However, this changed considerably in the 1970s in the US, and literacy became a focus in education worldwide. Green (1988, 1997) argued that literacy should be seen as having three interlocking dimensions of learning and practice: *operational*, *cultural* and *critical*. The *operational* dimension focuses on language aspect of literacy which involves reading and writing in a range of contexts in an appropriate and adequate manner. The *cultural* dimension focuses on understanding texts in relation to contexts while the *critical* dimension involves awareness of all social practices and thus all literacies are socially constructed. Gee (1990) goes on to say that since the 1980s and 1990s, the term literacy has been applied to an ever increasing variety of practices.

At present, the term digital literacy is of profound importance due to the rapid development of technology and its use in schools today. Digital literacy is defined as the ability to understand information in multiple formats from a wide variety of sources when it is presented via computers through the medium of the Internet (Gilster, 1997; Lanham, 1995; Pool, 1997). A global network such as the Internet makes it possible to develop and immediately disseminate a new technology of literacy to every person who chooses to access it online. The Internet, possessing the potential to contribute to the continuous redefinition of literacy, has been a major factor in making literacy deictic (Leu, 2000; Leu, Kinzer, Coiro & Cammack, 2004).

Literacy is now seen to be deictic, and is continually and rapidly changing as new technologies appear and new social practices for literacy emerge. That is making students relate to the meanings of the words used within a given context but which are presented in different digital formats. For example, using animations to describe a chemical equilibrium system. One strategy for reform utilizes new technologies, mainly information and communication technologies (ICT) to expand the learning opportunities for students (Anderson, 2008; Gee, 2004; Lam, 2006; Leander, 2007, Thomas, 2008). Technological tools can provide a venue for rich investigations, providing both access to data and powerful analytical tools. Such tools can provide scaffolding to support scientific practice and can be integral in new classroom inquiry practices. To be effective, use of these tools must be embedded in *technology-infused curricula*, that contain articulated problem contexts, tools, and resources so that students can work through investigations crafted to engage them in the target learning outcomes (Leander, 2007; Leuhmann & Frink, 2012; Webb, 2005).

The current literature describes ICT in terms of *Web 2.0 Technologies,* collectively known as *New Media Literacies* (NML), (Gee, 2003; Jewitt, 2008; Leuhmann & Frink, 2012; Livingston, 2003; Rodrigues, 2010). *Web 2.0 Technologies* also known as *e-learning 2.0* which generally support the notion of constructivist style of learning (Downes, 2005), allows for easy viewing and creation of content along with capability for sharing, editing, commenting, connecting or tagging, all means which allow others to interact with the content created. Lankshear and Knobel (2008), together with O'Reilly (2005), purport new literacies to be diverse, dynamic, immediate, interactive, and multimodal, rapidly evolving and a requisite for living and learning in the age of ICT. O'Reilly, (2005) further associates NML with *Web 2.0 Technologies* which allows participation, distributed expertise; collective intelligence sharing over ownership, which is different from what was possible with *Web 1.0* products also known as *e-learning 1.0* which has been associated with a transmission or behaviorist style of learning (see Table 3.1).

NML is then a theoretical framework that has been used to explore the participation opportunities made available through these emerging technologies. NML are used for three key purposes, namely (1) *accessibility* to a variety to people and resources,

(2) *connectivity* helps as a social tool to share information and ideas through the webbed structure and finally (3) *multiple modalities* for expanding the mediating practices which helped construct relationship and knowledge (see Table 3.2). NML redefines literacy as not just reading and writing but rather, the process of practice of meaning making within social networks (Gee, 2003; Hull & Schultz, 2002; Lankshear & Knobel, 2008; Leuhmann & Frink, 2012). That is, the focus of NML is that knowledge is shared through collaboration and distributed expertise and authority. A summary of *Web 2.0 Technologies* and related practices is presented in Table 3.3 (from Leuhmann & Frink, 2012)

Table 3.1: Some typical examples of *Web 1.0* vs. *Web 2.0 Technologies* (Adopted from Lankshear & Knobel, 2008)

Web 1.0	Web 2.0
Ofoto	Flickr
Britannica Online	Wikipedia
Personal Websites	Blogging
Publishing	Participation
Content Management Systems	*Wiki*
Directories (Taxonomy)	Tagging (Folksonomy)
Netscape	Google

Table 3.2: Linking science education goals with NML affordances (Adopted from Fraser, 2012)

Reform based Science Goals	NML Affordances
Engaging Students in: • Collaborative investigations over time • Productive public communication of ideas and work	*Prioritizes:* • Participation in developing global community • Collaboration • Distributed knowledge
Enabling Students to: • Provide evidence-based argumentation and explanations • Analyse and synthesise data and defending conclusions	*NML are:* • Openly authored, placing the requirements for evidence on the author • Situated practices in both the type of technology and the way it is used • Transactional processes that invite experimentations and pushing boundaries • Multiple, multimodal, and multifaceted
Students develop: • Understanding, abilities, and values of inquiry • Knowledge of science content	*Requires:* • New social practices, skills, strategies and disposition for their effective uses

Table 3.3: *Web 2.0 Technologies* and current related practices (Adopted from Fraser, 2012)

Web 2.0 Technologies	Related Practices
Publishing and Commenting a. Blogging b. Pod/vodcasting c. Micro-blogging d. Streaming media e. Audio/video commenting	*User-centric organizing of content and tools* a. Employing really simple syndication b. Building mashup applications c. Creating compound documents
Socially constructing and categorizing content a. Co-constructing *wiki* b. Sharing documents c. Video/photo sharing d. Creating media mashups	*Communicating in real time* a. Text-based instant messaging b. Audio/video instant messaging c. Document and application sharing
Connecting to people and information a. Social networking b. Social bookmarking/folksonomy/tagging	*Interacting in complex interactive environments* a. Gaming b. Participation in simulations c. Engaging in multiuser virtual environments

As shown in Table 3.2, there are interesting parallels between NML and reform-based vision for science education, since both represent a paradigm shift from traditional transmission model of learning evident in many schools. Traditionally, lessons are about 50 minutes in duration, run in synchronous class periods, and geographically constrained by four walls of a building. On the other hand, the reform based vision involves carefully designing ‘classrooms’ which allow engagement with *Web 2.0 Technologies* and which provide teachers and students participation structures not common and sometimes not possible within traditional classroom learning (Anderson, 2002; Coiro, Knobel, Lankshear & Leu, 2008). For example, students could collaborate with telementors from Geological and Nuclear Science (GNS) when doing an inquiry on volcanoes and then share this with the rest of their classmates for feedback within the 50 minutes period using *Web 2.0 Technologies*. Classroom applications required for NML realizes a potential shift in mindset which is a critical factor to catalyse connecting the learning opportunities and the specific uses of a tool. Next, Section 3.3.2 discusses some approaches using NML for supporting ambitious science learning in classrooms.

3.3.2 NML and its Potential for Integration With Classroom Practice

To benefit from the learning affordances identified above using *Web 2.0 Technologies*, participants must shift the way they consider possibilities, goals and ways to achieve these goals (Davies, 2006; Lankshear & Knobel, 2006, 2008; Leander, 2007; Robertson, 2008). NML represents a dramatic shift in how we interact with one another and what we value. Greater value needs to be given to actions and knowledge that are dispersed over those initially held, tools used for mediation and relationship building over those used for knowledge production. The focus is on the collective rather than the individual, and a move towards digital multimedia spaces rather than just using textual spaces (Lankshear & Knobel, 2006, 2008; Leander, 2007; Leuhmann & Frink, 2012).

The literature further suggests that in order to create inquiry classrooms in which students learn through investigation requires basic changes in *the rules of the game* for science classrooms; new curricula and tools must be accompanied by new teaching approaches and an explicit attention to shifting students’ attitudes toward science and science learning. Engaging students in this type of learning requires different values and expectations. It requires creating a different type of classroom culture (Brown & Campione, 1994; Crawford et al, 1999; Duschl, 1990).

On one level, it is probably impossible to find out how all students might be learning with ICTs out-of-school, but case studies as discussed in Section 3.1, do suggest rich or 'indicative' insights and it is these insights which guide our understanding about the nature of the learning that might be going on when students' are using computers in their home. Gee's (2003, 2004) foundational work on the learning principles informing participation in video gaming, as well as his discussion on online spaces when looking at gaming communities highlights the powerful affordances of these technologies hold for learning. He also says that these affordances may not translate to classroom learning because of differences in participants' motivation and purposes for engagement. Another factor which influences these affordances is the teachers' attitude and beliefs regarding how knowledge is constructed and the roles offered and taken by students (Annetta, Murray, Laird, Bohr & Park, 2008; Leander, 2007). A common thread seems to repeat itself as we examine this research. The kinds of learning demonstrated both complements and supplements learning going on in schools and this has two implications:

- That teachers, parents and other educators need to find a way beyond 'narrow' or simplistic definitions of learning and education to value and build upon the learning described in this study to enrich and support the curriculum; and
- That the kinds of knowledge and the modes of learning exemplified in out-of-school informal learning is very relevant to learning (see Section 3.1 & 3.2), how to become a modern kind of worker and that the formal education system needs to find ways to integrate with this kind of learning as a valid curriculum aim.

Furthermore, there is potential for use of *Web 2.0 Technologies* in classrooms, however, there is very little research on this topic in science education literature, especially of an empirical nature. Therefore, this Section discusses multimodal instructional practice (of different modes of communication to make meaning) using *Web 2.0 Technologies* within the social sciences and linguistics disciplines (Black, 2007; Carlone & Johnson, 2007; Gee, 2004; Kress & van Leeuwen, 1996, 2001; Lam, 2006; Leander, 2007; Leuhmann, 2008; Norris, 2004; Scollon & Wong-Scollon, 2003; Thomas, 2008).

NML allows for multimodality, which opens up meaning making to a multiplicity of modes of communication. This process of hybridizing students' resources for representation and dominant classroom practices can produce *transformative* or *fusion* pedagogies (Millard, 2006; Stein, 2007). The reflective, social and flexible nature of *Web 2.0 Technologies* makes them ideal to support students learning. A review of the literature reports that researchers have taken advantage of the multimodality features of *Web 2.0 Technologies* to encourage 'non-linear thinking', where new decisions were made as the designs emerged (Archer, 2007; Beach and O'Brian, 2005; Brenner & Andrew, 2006; Carlone & Johnson, 2007; Newfield, Andrew, Stein & Maungedzo, 2003; Smagorinsky, Zoss & O'Donnell-Allen, 2005).

Brenner and Andrew (2006) used this feature with pre-university students who were gaining entrance into degree programmes and were from disadvantaged backgrounds. This course was aimed to develop student's critical engagement in visual discourses and their academic writing in English. The findings from this research revealed grouping of students which enabled students to achieve in ways they needed to, and working with students in groups on an on-going basis. Likewise, Smagorinsky et al (2005) explored the use of multimodality as an instructional practice to explore identities with at-risk students. The multimodality features of *Web 2.0 Technologies* allowed mask-making project which was year-long exploration of self- identities. Instead of making the traditional mask using low technology methods, students used portfolios, reading logs on literary texts, drew life maps, to construct how they saw themselves and how others saw them. This type of innovation encouraged non-linear thinking, where new decisions were made as the designs emerged. The multimodal feature encouraged creativity which was reportedly more enjoyed by students than standardised tests.

Several other cases which are discussed next, reports on the benefits of using the multimodal features of *Web 2.0 Technologies* which enabled its use beyond using text only. Carlone and Johnson (2007) used *Web 2.0 Technologies* to support changing identities of pupils. In a similar attempt to engage at-risk students in South-African township school, Newfield et al (2003), used *Web 2.0 Technologies* to stimulate disaffected Grade 11 students to return to poetry which they found "too difficult". This was another project on identity exploration which used modalities beyond text and enabled them to work with language in productive ways.

While the results of using multimodal features proved beneficial at secondary school, studies at tertiary level had a similar experience. Archer (2007) reported on a related pedagogical project in multimodalities in a first year communication course in South-African university engineering programme. Students in this project identify an everyday object from their life world which has symbolic meaning to them. They examine these objects in a range of physical, cultural and communicational texts. Students produce a text in any media that discusses the physical characteristic and the uses of the object. Through this process, the artefacts become conduits to knowledge, histories, memories and relationships to others, and habits and values. Since the project took place in the beginning of the year, it enabled students within a less regulated curriculum space to draw on under-valued knowledge; these include indigenous language, local knowledge, religious meaning, personal experiences and multimodal competencies.

As mentioned earlier in Section 3.3.1, new media literacies are deictic which enables students to comprehensibly analyse information. In another study, Beach and O'Brian (2005) explored multimodal pedagogies that foster critical inquiry. They described the uses of hypermedia can foster 'intercontexual links' that can lead to critical inquiry in which students interrogate the instructional and ideological forces shaping uses of texts. Traditionally, students were asked to link texts in multi-genre writing, where students could make intertexual links across written texts. In this case, the students were encouraged to make hypertextual, virtual connections in hypermedia productions, for example using PowerPoint. Drawing on Barthes' (1974) notion of intertexuality, in which every text being itself, to a shift where the focus of meaning construction from authorial intent to how text references multiple discursive contexts. In the *Web 2.0 Technologies*, the shift from page to screen, where media texts and intertexts can actually reside out there in a virtual space in the networks students access. This helps students to access the information in infinite ways depending on how they access it. The important point here is not only the products that students produce, but the process of ‘multimediating’ (Doneman, 1997; Lankshear & Knobel, 2003). In other words how they create and use texts to play against or complement each other. In making intertexual links, students can ‘uproot’ text from one context, transport it into another context and thereby ‘recontexualising’ the meaning of that context. To read intertexually, or integrate two texts, a learner must generate inferences that connect the present text to the knowledge derived from previous text. These inferences are generated when the correspondence between elements is recognised and used to map the two representations (Gernsbacher, 1990; Hayes-Roth & Thorndyke, 1979). Integration, the cognitive process by which mapping occurs, requires that both representations are held simultaneously in working memory (Coté & Goldman, 1999; Van Meter & Garner, 2005). For example, the student researching about energy transformation could use the basic principle and texts from one site such as hydro power and use graphics to show how this occurs in perhaps rubbing your hands.

While *Web 2.0 Technologies* in theory, opens up landscape in ways that can bring students from different socioeconomic backgrounds in ‘closer conversations’ with academic literacy, the dynamics of access and mechanisms of exclusion are much more complicated (Hartman, 1995, Van Meter, 2001; Van Meter & Garner, 2005; Tabachneck-Schijf & Simon, 1998; Thesen, 2001). The majority of studies focussing on NML are critical of the narrowness of what counts to be learning and communication in temporary classrooms. Researchers have cautioned against elevating multimodality to a ‘pedagogical holy cow’ ((Hartman, 1995, Van Meter, 2001; Van Meter & Garner, 2005; Tabachneck-Schijf & Simon, 1998; Thesen, 2001). The literature suggests that although evidence exists that students generate these connection, intertexual integration does not happen to the degree that we like (Hartman, 1995, Van Meter & Garner, 2005). Studies which considered cross-modal integration found that students could not link text and graphic representations when learning economics principles in hypertext environments (Tabachneck-Schijf & Simon, 1998; Van Meter, 2001).

A review of literature suggests that when readers integrate across textual representations also known as intertexuality, knowledge acquired is of higher quality than knowledge derived from a single source. That is, readers must connect representations of knowledge to construct internal representations that are supportive of deep understanding and problem solving (Hayes-Roth & Thorndyke, 1979; Perfetti, Britt & Georgi, 1995; Van Meter & Feritto, 2008; Van meter & Garner, 2005). However, for students to benefit from integration of textual information, they are likely to need instructional direction and support to do so. Intertexuality is now becoming an ever more important issue since students now operate in a world of NML, which contains a vast array of texts. Unfortunately, emerging models of learning in NML have focussed on search and navigation and less on students' comprehension processes (see Hoffman, Wu, Krajcik & Soloway, 2003; Kulikowich, Edwards, Van Meter & Higley, 2005). Section 3.3.3 exemplifies features of NML with reference to recent technologies, namely, *blog* and *wiki* which are considered as second-generation Web applications (Thorne, 2008; Thorne & Payne, 2005).

3.3.3 *Social Software Technologies*: *Blog and Wiki*

For the past 30 years, there have been more than 400 national reports calling for fundamental changes in how we educate our children, particularly in mathematics and science (Hawley, 2002; Hurd, 1994; NRC, 1996). These reports call for reforms aimed at developing scientific habits of mind or ways of thinking, by having students take a more active role in learning of science content that has current relevance. Science is more than just an elaboration of concepts, ideas and theories because it is founded on an innate curiosity about the nature of the universe, which is only satisfied by active pursuit of learning (Crawford, 2000; Shuell, 1987). Science is a dynamic discipline, which focuses on solutions of problems, on questions and on unknowns, and so it is important to establish environment where useful information is generated and intertexuality of multiple data sources are used to develop more meaningful and integrated knowledge (Knorr-Cetina, 1992; Roth, 1995; Spier-Dance, Mayer-Smith, Dance & Khan, 2005; Varelas & Pappas, 2006). Internet pedagogy, one of the several new literacies now emerging in our schools and in society at large has potential for pursuing these science education reform goals (Heil, 2005; Lankshear & Knobel, 2003; McFadden, 2001). This potential could be realised by a number of enabling tools (see Gee, 2004), which allows for participation, collaboration, distribution and dispersion of expertise and relatedness.

Recently social software technologies such as Weblogging, Wikipedia, Podcasting and Virtual Classrooms have emerged. The next section, briefly considers affordances of two *Web 2.0 Technologies* namely *blog* and *wiki* which are used in schools today. There will also be some discussion on the limitations of these two Web applications.

As noted above, affordances of *Web 2.0 Technologies* are seen as an essential component of supporting students learning environment. Amoung these technologies, weblogs ('*blogs'* hereafter) seem especially promising as tools to support collaborative and reflective learning (Davies & Merchant, 2007; Leuhmann, 2008; Leuhmann & Frink, 2012; MacBride & Leuhmann, 2008; Rezak & Alvermann, 2005). *Blogs* are frequently updated webpages with a series of archived posts, typically in reverse-chronological order. Most *blogs* posts are primarily textual, but they may contain images, photos or other media content. Almost all *blogs* provide hypertext links to other Internet sites, and most allow for audience comments (Henning, 2003; Nardi, Schiano & Gumbrecht, 2004; O' Riley, 2005).

Much has been written about the potential of *blogs* to support learning (Carlson, 2003; Downes, 2004; Ferdig & Trammell, 2004; Huffaker, 2005; Leuhmann, 2008, Leuhmann & Frink, 2012; Martindale & Wiley, 2004, Poling, 2005; Richardson, 2003, 2006). The literature suggests that blogging affordances in classrooms allow for the following (Leuhmann & Frink, 2012; MacBride & Leuhmann, 2008):

- Promote reflective thinking;
- Nurture collaboration and relationship building;
- Increase perceived accountability and therefore quality of student work;
- Increase opportunities for students to receive feedback;
- Allow and encourage interactions with telementors; and
- Provide the teacher with a unique window into student thinking.

Table 3.4: Characteristics of *forum*, *blog*, and *wiki* (Adopted from Miyazoe & Anderson, 2010)

Characteristics	*Forum*	*Blog*	*Wiki*
Time orientation	Past and present	Past to present	Present
Presentation	Threaded	Reverse chronological	Final product
Structure	Controlled by moderator	Controlled by author	Open
Administrators	One/many	One	Many
Editing	Not allowed	By creator	By many
Consciousness orientation	Process	Process	Product
Work mediation	Collective	Individual	Collective
Activity orientation	Exchange	Express	Change
Mood-relevant Orientation	Cooperative	Individual	Cooperative

However, the literature also informs that although much has been written, little of what is published is empirically based and even less of that work has been peer-reviewed (MacBride & Leuhmann, 2008, Leuhmann & Frink, 2012; Williams & Jacobs, 2004). This presents an opportunity for future work. Also, early experiments with blogging have been mainly carried out in higher education. While the claims are thoughtful, insightful and compelling, it is clearly important to consider implementation issues and impact of classroom blogging that are *unique* to a high school learning context. The literature also cautions that blogging affordances in a classroom practice is not simply a matter of correct design, but lived practices determined by both how students took up the design (or not) and how the teachers responded to students participation, contributed to the resulting benefits of classroom blogging (Leuhmann, 2008, Leuhmann & Frink, 2012; McBride & Leuhmann, 2008). Also, some findings suggest that students did more than what was asked of them in the teacher designed activity structure; in these instances, blogging enabled students' access to additional resources and opportunities for learning such as hyperlinked and multimodal resources, a broader community and audience and additional and different opportunities to engage peers and the teacher (Leuhmann, 2008, Leuhmann & Frink, 2012; McBride & Leuhmann, 2008). The additional resources such as hypertext links encouraged intertexuality and collaboration with works of scientists and others in the same area. Furthermore, the learning benefits of blogging were connected to two primary and complementary conditions (Downes, 2004; Leuhmann, 2008, Leuhmann & Frink, 2012; MacBride & Leuhmann, 2008): the presence of an active blogging community and the investment of the blogger.

A review on blogging reports that teacher's instructional design of classroom blogging to be effective should have *four* distinct components (Leuhmann, 2008, Leuhmann & Frink, 2012; MacBride & Leuhmann, 2008). These were: curricular goals, instructional priorities, activity structures, and contents of rollout to students. An active blogging community was nurtured through publishing detailed posts, soliciting input, referencing others work, and offering detailed description of issues (Leuhmann & Frink, 2012; MacBride & Leuhmann, 2008). For example, students could use their own choice of tools such as graphing tools, formatting tools, and so on, and multi-coloured texts to prepare representations such as graphs and texts, to articulate their scientific understanding of Kinetic Theory. This form of group participation allowed and encouraged students to bring their NML skills to bear on their science learning.

In summary, blogging, like all *Web 2.0 Technologies*, holds potential for scientific work to emerge through students and teachers initiative. The realised benefits of classroom blogging is not simply a matter of correct software design, but determined by the lived practices of the students, showing positive interdependence with one another, the length of blogging experience and the degree of student autonomy as well as teachers response to students participation. The second social software technology, *wiki* is discussed next.

The social software technology, *wiki* is an online technology, which is purported to support communication, collaboration and knowledge building (Bonk & Dennen, 2007; Juwah, 2006; Richardson, 2003, 2006; Robertson, 2008). *Wiki* (from the Hawaiian word *wiki wiki* meaning "quick") describes a web-based environment that supports collaborative writing. First developed by Cunningham in 1995, *wiki* are designed as a solution to making publishing an easy process (Augar, Raitman & Zhou, 2004; Choy & Ng, 2007; Molyneaux & Brumley, 2007; Richardson, 2006). Subject to access settings, *wiki* provides a relatively simple interface that allows webpages to be created and edited by anyone at any time. It is also possible to incorporate text, audio, images, video and hyperlinks to other webpages. *Wiki* are designed to be intensely collaborative and allow multiple users to edit content and contribute to the production of continually evolving texts and informational resources. Godwin-Jones (2003, p. 15) describes the *wiki* site as way of "achieving collective applied learning with the expectation that over time, expertise in a given subject area is developed and solutions to common issues and shared problems are found, posted and discussed." For example, a research project team might set up the *wiki* for the purpose of collaborative writing of their project on *volcanoes* and generating articles for their research. The teacher can make the *wiki* password protected, so that only members of the team can read and edit the content. The radical dimension to *wiki* use is its challenge of the notion of authorship. That is, there is no distinction between 'author' and 'audience' (Lankshear & Knobel, 2008; Thorn, 2008, Thorn & Payne, 2005). All changes are logged on *wiki*, so it is possible to know when a change was made to content and who made this particular change.

Also, anyone with access to the *wiki* will automatically receive information when a change has been made. The literature reports overwhelming support for the flexibility that *wiki* provided in allowing the students to access and use the software at a time and place which best suited them. Another result was having an excess to a single central document where previous edits can be tracked. Furthermore, the use of *wiki* replaces the need for submission of a hardcopy report. However, the literature suggests that while the potential of *wiki* to support collaborative learning is received with high optimism, the potential is yet to be fully realised (Kennedy, Dalgarno, Gray, Judd, Waycott, Bennett, Maton, Krause, Bishop, Chang & Churchward, 2007; Schwartz, Clark, Cossarin & Rudolph, 2004).

Wikipedia is probably the most popular *wiki* website in the world today because so many people use it for research on various topics. Its name is a mix of *wiki* and encyclopedia and acts as a secondary source for further reading and as a source for historical facts and figures (Lankshear & Knobel, 2008, Thorn, 2008). O'Reily (2005) identifies Wikipedia as a *Web 2.0* initiative that embraces the power of the Web to harness collective intelligence. That is, the principle of maximising user activity to generate more valuable outcomes. Its contents far exceed that of what is found in typical encyclopedia books. Wikipedia is located at the open end of the continuum, which is open content *wiki*. But, there are also other *wiki* available on the Internet. These other *wiki* have a more focused content. Examples are *wiki* sites about certain games and topics (Lankshear & Knobel, 2008; O'Reily, 2005; Thorn, 2008). They may not have the great number of users, but the more focused topics mean one can get more details on the topic you want. The *wiki* sites, more importantly Wikipedia, have changed how people view and collect information on the Internet.

In summary, *wiki* is a type of website while Wikipedia is a website that uses the *wiki* format. Wikipedia is arguably the most popular *wiki* in the world. Wikipedia emulates an encyclopedia while other *wiki* may contain other types. Wikipedia has a 'community' character to it, so there seems to be certain shared feeling that it is valuable source and needs to be maintained properly; that is, shared ownership of knowledge. It promotes and celebrates the values of inclusion, mass participation (unless controlled), distributed expertise, valued and renewable roles for all that pitched in, free support and advice building the practice, collective benefit, cooperation before competition and everyone is a winner.

3.3.4 Section Summary

In summary, NML demands attention on how students integrate across texts. In this Section, the focus has been on the context studied, but in today's information society, students are expected to deal with an array of knowledge resources. They have to contend with both on and offline texts, classmates' postings, and email correspondence. *Web 2.0 Technologies*, allow for inclusion of complex nonverbal arrays within learning environments. If we are to offer an intervention that assists them in these environments, we must address not only the way they navigate, but also, how they integrate these resources to enhance their understanding of science concepts. Blogging and *wiki* are a potentially engaging and valued means of communication amoung students; it seems worthwhile to consider the potential of using these second-generation Web applications in secondary school science classrooms. New Zealand schools are using *Web 2.0 Technologies* software called *Modular Object Oriented Dynamic Learning Environment* (MOODLE). This is a Learning Management Systems (LMS) which has a number of operational features which are for both, administrative as well as has affordances for use in classroom practice. Section 3.4 highlights some of these features and their use in education.

3.4 Learning Management Systems (LMS)

A learning management system (commonly abbreviated as LMS), with origins in human resources and training activities within, is a product which was developed from the merger of world's two largest propriety e-learning systems (Blackboard, 2005; Downes, 2005; Siemens, 2004b). A learning management system is a software application which enables human resource organizations to create, document, deliver, track, measure and evaluate (corporate) learning programs to create a high-performing workforce. In terms of its use in education, particularly for higher education, this merger meant that this software could potentially improve online learning experiences (Blackboard, 2005; Downes, 2005; Hall, 2003; Siemens, 2004b). This was proposed to bring e-learning community together, broaden access to shared expertise, reuse technologies, faculty and develop networks, and for the promotion of exemplary course programmes amongst e-learners in a global community (Blackboard, 2005; Downes, 2005; Siemens, 2004b, 2005).

The section begins by describing some of the background, drivers of LMS and its core learning functions. Following this, there is discussion on research trends in LMS and its potential for integration into teaching and learning. The last part of this section considers research findings on student learning outcomes using LMS as a mode of delivery of online courses. Section 3.4.1 discusses some core learning functions of LMS and its historical inception in the business sector.

3.4.1 LMS: Background, Drivers and Learning Functions

LMS grew from a range of multimedia and Internet developments in the 1990s. In the last four years, these systems have matured and been adopted by many universities across the world (Baskin & Anderson, 2008; Coates, James & Baldwin, 2005; Hall, 2003; Siemens, 2004b). They are variously referred to as *'learning platforms', 'distributed learning systems', 'course management systems', 'content management systems', portals, and 'instructional management systems'*, as LMS combine a range of course or subject management and pedagogical tools to provide a means of designing, building and delivering on-line learning environments. Additionally, some LMS used by business organizations include "performance management systems", which encompass employee appraisals competency management, skills and succession planning.

Over the last 20 years, technology has reorganized how we live, how we communicate and how we learn. LMS were identified as a second generation response to organizational learning needs (Daniel, 2003; Robbins, 2002, Siemens, 2005). With the advent of the Internet came the opportunity to integrate the functionality of LMS so that they could be utilized to enable planning, tracking, measuring and evaluation of employees, customers and stakeholders. A LMS is then part of a strategic infrastructure; it is a significant component of how every higher educational institution sees and positions itself in terms of its connections to the local, national and global higher educational markets and agendas. The adoption of LMS at universities is typically based on the following reasons (Coates et al., 2005, Daniel, 2003):

- To increase efficiency of teaching by allowing institutions a means for delivering large-scale resource based learning programmes, which helps to facilitate flexible course delivery, helps in collaborative work, communication and conferencing, student management and support (Ryan, Scott, Freeman & Patel, 2000);
- The attractiveness of LMS is associated with the promise of enriched student learning since the online learning systems are seen to reinforce and enhance a diverse suite of constructivist pedagogies which helps to make the course content more cognitively accessible to individual students by allowing them to interact with diverse, dynamic, associative and ready-to-hand knowledge. Also, LMS may also enrich learning by providing automated and adaptive formative assessments which can be individually initiated and administered (Gillani, 2000; Jonassen, 1995; Jonassen & Land, 2000; Relan & Gillani, 1996);
- Universities are expected to have leading edge technologies, in order to cater for a growing number of students who have an 'information-age mindset', the n-generation (Frand, 2000; Gilbert, 2001; Green & Gilbert, 1995);
- Competitive pressure between universities to cater for distance-learning programmes (Garrison & Anderson, 2003);
- Due to an increasing demand for greater access to higher education, LMS helps overcome the limitations of physical infrastructure (Daniel, 1998; Dearing, 1997; Gilbert, 2001; Hanna, 1998; Johnstone, 1995; Moe, 2002); and
- LMS is becoming a part of an important cultural shift taking place in teaching and learning in higher education. LMS may appear to offer a means of regulating and packaging pedagogical activities by offering templates which assure order and neatness, and facilitate the control of quality. This provides a persuasive reason for their rapid uptake in higher education and now in most New Zealand secondary schools also.

In higher education, the affordances of LMS allows for lifelong learning, self-paced learning, flexible learning, situated learning and collaborative learning. This is what Lemke (1996) termed the interactive learning paradigm where learning is predominantly a networked (connected) activity. Many conventional learning processes can now be embedded in technology, mainly *Web 2.0 Technologies* (discussed in Section 3.3), which operates through the dominant platform of delivery of e-learning, that is, the Internet (Baskin & Anderson, 2008; Downes, 2005). The corollary of this is the need for a mechanism to manage such delivery which could be achieved via LMS. The main 'client' relationship featured in this kind of system is that of the learner and the learning provider. LMS offers the greatest value to the organization by providing a means to sequence content and create a manageable structure for instructors and administration staff (Baskin & Anderson, 2008; Siemens, 2004a). Siemens (2004a) and Brusilovsky (2004) assert that LMS makes learning simple by doing everything for the student. This he claims to be a weakness of LMS, since they are designed as a learning management tool and not a learning environment tool. Below is a summary of core learning functions built around this kind of system (Baskin & Anderson, 2008):

- Controlled access to curriculum that has been 'chunked' for discrete assessment and reporting;
- Tracking student activity and achievement against this curriculum through simple administration tools;
- A structured learning resource base and facilitated assessment suite;
- Communication between the learner, provider, and learning technicians to support learner feedback; and
- Group communication suites to support collaborative learning.

However, only recently (and in limited ways) have LMS, started to extend their tools and offer more than simple content sequencing and discussion *forums* as described above. That is, a place for content interaction, a place to connect with other students and place to dialogue with teacher/instructor; in other words, a place for higher connectivity with other students (see Appendix A).

Academic institutions have seen a steady increase in the use of learning management systems such as Blackboard, WebCT, Moodle and Sakai (Coates et al, 2005; Jackson, 2007). While WebCT and Blackboard are listed as the most popular LMS in tertiary institutes globally (Jackson, 2007), Moodle is more commonly used in secondary and tertiary institutes in New Zealand. Moodle, an acronym for *Modular Object Oriented Dynamic Learning Environment*, is a free software e-learning platform. Moodle was originally developed by Martin Dougiamas to help educators create online courses with a focus on interaction and collaborative construction of content, and being open source is in a state of continual evolution. The stated philosophy of Moodle includes a social constructivist approach to education, emphasizing that students (and not just teachers) can contribute to the educational experience (Baskin & Anderson, 2008; Bentley, 2003; King, 2002). Using these pedagogical principles, Moodle provides a flexible environment for learning communities. Moodle has several features considered typical of an e-learning platform, plus some original innovations, like its filtering system, which means that log files can be filtered by course, participant, day and activity. Moodle can be used in many types of environments such as in education, training and development, and business settings. Some typical features of Moodle are: Assignment submission, Discussion *forum*, File download, Grading, Moodle instant messages, online calendar, online news and announcement (at Institute and course level), online quiz and *wiki*.

While many universities are investing heavily on e-learning infrastructure and architecture, the research literature on e-learning strategies primarily appear to be made with regard to cost and efficiency savings rather than to any commitment to improve teaching and learning from a pedagogical basis (Basin & Anderson, 2003; Hall, 2003). Sproull and Kiesler (1986) together with Blasi and Heinecke (2000) and Lambier (2002) express concern about the absence of nonverbal cues in the LMS. They say it follows that where digital communication suites are involved, we are less able to make subtle differentiations amoung communication stimuli and therefore less able to exert control over ourselves in order to meet social expectations and perform important social roles. Sproull and Kiesler (1986) contended that this is more likely to lead to role ambiguity, increased anonymity, reduced self-regulation, and reduced self-awareness; that is LMS as counterproductive to learning.

However, other authors celebrate LMS and argue it has an intrinsic social presence. The nature of a LMS it is posited, is consistent with a social constructivist theory of learning, which presupposes that learning is best achieved in social environments and that any form of communication (virtual or real) can be used to enhance the social presence of others and thereby facilitate learning (Anderson, 1995; Downes, 2005; Siemens, 2004a; Short, Williams & Christie, 1976; Wolfe, 2000). This new type of social space and its social networking features can then facilitate numerous types of interactions, whereby students can develop a new sense of 'self' and 'community'; something that can be mediated, negotiated and if necessary continuously renegotiated. To effectively integrate LMS into schools for teaching and learning, the facilitator must emphasise the meaningfulness of the learning materials, rely on learner-centered instructional approaches, provide positive interpersonal exchange and attend to a host of student diversity issues (Murray, 2004; Partee, 2002; Schwitzer, Ancis & Brown, 2001; Stiles, 2002). Section 3.4.2, which follows, discusses LMS and their potential in teaching and learning.

3.4.2 LMS: Teaching and Learning

The research literature regarding the importance of interaction in education especially in web-based learning is now quite extensive. There have been a large number of studies and position papers on the relationship of interaction and learning (Jonnasen, Peck & Wilson, 1999; Lamb, 1992; Sponder & Hilgenfeld, 1993; Vogel & Klassen, 2001). Many studies say that when using interactive materials, students not only learn more, and more quickly and more enjoyably, they learn the much needed life skill of learning how to learn; that is, they begin to take ownership and responsibility for their own learning (Hartman & Truman-Davis, 2001, Siemens, 2005). Within teaching and learning exchanges, according to the literature there have been three key changes in a shift away from a dominant cognitive view of learning to concept of communication, concept of interaction and conceptual model of context (Anderson, 1995; Hymes, 1970; Siemens, 2005; Wolfe, 2000).

As noted above, social constructivism underpins the research of this thesis. Driscoll (2000) and Wertsch (1991) say that the *social presence* is a critical component of learning, together with the, *transactional distance* and *social affordance*. They argue that these three elements 'conspire' to create the right conditions for teaching and learning, and this can constructively align in a LMS. The *social presence* here means how 'real' (or three dimensional) a person or group appears to be in a virtual world, despite the medium of communication (Richardson & Swan, 2003; Stein & Wanstreet, 2003; Short, Williams & Christie, 1976). The LMS thus represents expressions of virtual relationships. For example, if a teacher emails lecture notes to students; this establishes an immediate and 'special' contact, compared to the more traditional classroom in which there may be large number of students and limited scope for definitive social presence. Furthermore, Moar (2003) says that interaction and corresponding perception of social presence of others grows from the use of social constructivist approaches to teaching and learning in an LMS-facilitated setting. Within social networks, he argues it is the well-connected people who are able to foster and maintain knowledge flow (Baskin & Anderson, 2008; Kleiner, 2002; Siemens, 2005). This interdependence results in effective knowledge flow, enabling the personal understanding of concepts under study. For example, when students are accessing a Moodle site to post their findings on a *forum*, if they have carried out say redox reactions in chemistry, they will be able to post more detailed observations for their learning group. Those which were unsuccessful in doing these experiments, due to lack of resources and/or facilities, will be able to draw upon their peers for support. So, if two groups had conducted redox reactions, then LMS becomes a way for them to collaborate and discuss their findings. LMS is used here as a learning platform which provides affordances for students to provide evidence-based arguments and explanations and analyse and synthesise data defending conclusions. This could be done by co-constructing, *wiki* and /or sharing documents or blogging/*forum*, using the NML described above.

This awareness of social presence as a structuring theory suggests that learning can be facilitated in such a way that the perception of social presence is increased by use of a LMS; this in turn greatly increases the ability to substitute ICT for face-to-face interactions while achieving the same learning outcomes (Gunawardena & Zittle, 1997; Richardson & Swan, 2003; Stein & Wanstreet, 2003). That is, the pedagogically informed use of a LMS shifts the focus away from technological events such as system components and capabilities back into critical teaching and learning events. A common misconception is that social presence is indicative of interaction (Picciano, 2002). A face-to-face classroom, by definition will have a high social presence; indeed the reverse is true if students or teachers feel alienated. Hence, social presence can be redefined as an outcome of intimacy and immediacy (which are themselves determined by the three dimensions of interactivity, social context, and online communication) (Garrison, Anderson & Archer, 2000; Gunawardena & Zittle, 1997; Tu & McIsaac, 2002). It does seem then that a LMS can enhance some less successful face-to-face teaching and learning situations.

Secondly, the pedagogical theory of *transactional distance* sits firmly within the learning theory of social constructivism. Dewey and Bentley (1949) derived the concept of learning transaction to mean a transaction in which a person 'shares learning' with the rest of his or her 'group' in a way that is dialogic; that is, the students show through dialogues an understanding of texts, values and issues discussed. Moore in the early 1970s formulated the theory of transactional distance, which was later defined as a 'psychological space of potential misunderstanding' between the behaviors of instructors and those of the learner (Moore & Kearsley, 1996; Mueller, 1997). However, Faust (2004) argued that transactional distance is really a pedagogical distance determined by the balance of teaching and learning, that is, structure and dialogue. The structure relates to the rigid/flexible nature of study, indicating the objectives, strategies and its capacity to accommodate learner diversity. For example, some students are able to articulate their thoughts by writing, while others draw diagrams to share the same information. This is very common when students have to discuss topics like photosynthesis and respiration in living cells. Dialogue, refers to purposeful, constructive, and valued interactions. In Moore's theory, if a taught course in highly structured but the dialogue is low, then there will be a larger transactional distance leading to psychological gaps. Differing teacher and learner behavior could increase the likelihood for misunderstanding between participating parties and it is much harder for learning to occur. On the other hand, if the dialogue is high and the structure is low (i.e., the learning environment is very flexible), then the transactional distance will be much smaller (Faust, 2004; Moore, 1993; Mueller, 1997). Moore (1993) and Mueller (1997) go on to observe that transactional distance is a subjective experience, and varies according to learner autonomy and dependency.

When applying theories of social presence and transactional distance to the use of LMS in teaching and learning, there is a possible explanation for the high value placed on face-to-face interactions (i.e., high dialogue) for large group teaching, and the possible failure of LMS (i.e., typically high structure, low dialogue) interactions for the same cohort of students (Garrison, Anderson & Archer, 2000; Richardson & Swan, 2003). Yet the literature suggests that the social context of education is affected by motivation and attitudes, as much as it is by teaching and learning (Foley, 2004; McInnis, 2003; Treleaven, 2004). The literature on social presence and transactional distance thus points to the context of use as a critical determinant of learning through a LMS.

A LMS is a 'pedagogical space' where the teacher and the learner may be geographically separated, but are connected via knowledge construction processes, and who communicate via discussion *forum*, submit assignments via email or digital drop box, within the LMS (Downes, 2005; Howard, Schnek & Discenza, 2004; Siemens, 2004b). Transactional distance within this context of learning is defined by the psychological and communication space between teachers and students. While communication properties of a LMS may trigger social interactions, they do not necessarily sustain or direct learning engagement within that environment, a phenomenon described as *social affordance* (Baskin & Henderson, 2005; Bradner, 2001; Wenger, 1998). This means that there is a need for tailoring educational experiences for the consumption of individuals; that is, using ICT as structuring resource for more effective teaching and learning (Kreijns, Kirschner & Jochems, 2002; Salmon, 2004). Salmon (2004) described this process as *e-moderating*; arguing that LMS programmes are designed to have relatively higher levels of social affordances. They do this by drawing upon elements from face-to-face teaching and traditional print-based teaching to construct new teaching and learning events, but Salmon (2004) identifies a need for introduction of a range of new understandings and techniques which are specific to e-learning delivery.

In summary, the logic of linking social affordance with e-moderating is profound. If social presence is an attribute to teaching and learning environment, and transactional distance frames teaching and learning events, then social affordance provides the means to design for better teaching and learning outcomes. Perhaps, an alternative could be to draw upon the best from both teaching and learning media, face-to-face and e-learning, what is often referred to as blended learning or blended courses.

Blended courses, also known as hybrid or mixed mode courses are a combination of both traditional classrooms and on-line methods, which are employed to deliver instructional content; these have proven to be a popular choice for many students (Dzuiban, Hartman, Cavangh & Moskal, 2011; Hartman & Truman-Davis, 2001). This popularity seems intuitive, because blended courses allow students to take advantage of the flexibility and convenience of an online course, while retaining the benefits of a face-to-face classroom experience. While many authors suggest that higher education has become fully online in most universities, many are struggling with conceptualizing a blended learning environment. The development and delivery of blended courses can be used to address a variety of institutional, faculty/departmental and student needs. For universities, the success of blended courses is part of a strategy to compensate for limited classroom space. For faculties, blended courses can be a method to influence new engagement opportunities into established courses or for some to provide transitional opportunity between fully face-to-face and fully online (Dzuiban, Hartman Cavangh & Moskal, 2011; Harman & Truman-Davis, 2001). For students, blended courses offer the convenience of online learning combined with the social and institutional interactions.

While, most of the research reported in the literature supports the relationship of interaction and satisfaction in web-based courses, some authors have cautioned that this is not always the case (Baskin & Anderson, 2008; Ruberg, Taylor & Moore, 1996; Sproull & Kiesler, 1986). It seems that in order to interact successfully, students must adjust to the non-linear, asynchronous nature of web-based learning; something that does not necessarily occur naturally. Typical face-to-face classroom situations tend to be linear, focusing on a single discussion thread, that is, they are synchronous in nature. However, web-based learning sessions are asynchronous and can have multiple threads with several discussions and interactions progressing simultaneously. Students may respond to the teachers and/or to other students. Sproull and Kiesler (1986) caution that asynchronous discussions may lead to developing misunderstanding if teachers do not immediately moderate discussions.

Other authors report a ‘sinking feeling’ that exits for integrating LMS into higher education curriculum (Dabbagh, 2002; Littlejohn, 2002; Macchiusi & Tinidad, 2000; McNaught, 2002; Morgan, 2003; Ramsden, 1992; Vogel & Klassen, 2001). Some of the concerns raised are at infrastructural level where for instance, Macchiusi and Trinidad, (2000), point to a lack of uniformity in enterprise-wide computer hardware and software systems in universities, even when the institution has adapted a commercial LMS. A consequence of this is that the roles of faculty members get more varied due to technology extending in a plurality of new directions (Vogel & Klassen, 2001). Morgan (2003) and Littlejohn (2002) report that most of the effort for integrating LMS into institutions is on converting the existing lecture-based learning programmes into modular materials which are distributed to the students with the traditional assignments and examinations as a sole means of assessment. While the LMS here is seen as an ‘innovation’ in teaching and learning, they say teaching and learning success stories featuring a LMS remain unsubstantiated (Baskin, Barker & Woods; 2005; Ramsden, 1992; Snyder, 1997; Tyner, 1998). Evaluation studies thus far, fail to reveal much of the anticipated improvements in learning outcomes (Alexander, 1999; Alexander, Mckenzie, & Geissinger, 1998; McNaught, 2002). Section 3.4.3, which follows, discusses some reported learning outcomes using LMS.

3.4.3 LMS: Student Learning Outcomes

As noted above, there has been a remarkable adoption of LMS by universities worldwide and less in schools to help facilitate flexible course delivery, use of resources, communication, collaboration, student management and support (Bates, 1995; Brown, 2002; Daniel, 2003; Dutton & Loader, 2002; Johnstone, 1995; Katz, 2003; King, 2001; Ryan et al, 2000; Turoff, 1997; van Dusen, 1997). However, being a relatively new technology, there has been no large scale studies of the actual uses and pedagogical effects of LMS on learning (Bell, Bush, Nicholson, O’Brien & Tran, 2002; Coates et al., 2005). A critical review of the literature shows that while the impact of learning management systems specifically the Blackboard interface which provides instructors with access to a powerful web-based instructional platform, to provide access to syllabi, course notes, interactive demonstrations, handouts, video and audiotaped lectures are all possible via this interface, few empirical studies have examined the impact of LMS on objective measures of student learning (Coates et al., 2005; DeNeui & Dodge, 2006). The literature goes on to suggest that most of the discussions about LMS seem to occur without consideration of their effects on students learning outcomes. It could be said then that students may view LMS as a general part of the university infrastructure, rather than as a special tool which adds value to their learning. As observed above, LMS are becoming more established in teaching programmes and it is useful to examine their effects on students' engagement and their learning outcomes.

Existing research has focused on students' self-reported perceptions of learning, rather than documented learning outcomes (Hiltz, Coppola, Rotter, Turoff & Benbunan-Fich, 2000; Richardson & Swan, 2003; Wu & Hiltz, 2004). Those that have used objective performance measures have reported somewhat mixed results for courses that employ online pedagogies. A number of studies have examined the relationship between student participation in online courses and their grades, and found no significant relationship between the two (Davies & Graff, 2005; Picciano, 2002). Many others have compared online and/or blended classes to traditional classes and again found mixed results (see, e.g., Fjermested, Hiltz & Zhang, 2005).

However, one of the first empirical studies, that conducted by DeNeui and Dodge (2006), sought to establish a link between students' usage of online components and overall success in the course. The authors report a significant positive partial correlation between overall usage and student exam scores. However, exam performance is only one method of assessing students learning outcomes, and so it is possible that the short term gains in students learning are not much influenced by LMS usage and that the real benefits shows up in students long term retention of course materials. While this may be true, future work should include post-class follow up measures to assess student retention of materials as well as ask students to self-report not only on how often they use LMS, but in ways they utilized the contents of the site.

Focus on short term apparent knowledge gains may not reflect other learnings. For example, personal knowledge is comprised of a network, which feeds into institutions, which in turn feeds back into the network via LMS and then continues to provide learning to the individuals using affordances of *Web 2.0 Technologies* such as *wiki* and *blogs*. This cycle of knowledge development may allow students to remain current in their field through the connections they have made (Baraba´si, 2002; Brown, 2002; Siemens, 2005). The literature also reports that the NML leverages the small efforts of many with the large efforts of few (Brown, 2002; Landauer & Dumais, 1997; Siemens, 2005). This means that connections created with unusual nodes or information sources supports and intensifies existing large effort activities. For example, a community college system project linked senior citizens with elementary school students in a mentor programme (Brown, 2002; Siemens, 2005). These children apparently listened to their grandparents better than their parents, and the mentoring were reported to have helped the teachers immensely, that is here the small efforts of the many (mentors), complement the large efforts of the few (teachers). This amplification of learning, knowledge and understanding through the extension of a personal network is considered by some authors as the epitome of social construction of knowledge (Brown, 2002; Landauer & Dumais, 1997; Siemens, 2005).

Consistent with this, many authors believe that learning is a continual process which lasts for a lifetime. Informal learning as noted earlier is a significant aspect of our learning experiences and formal education no longer comprises majority of our learning. Learning now occurs in a variety of ways; through personal networks using NML either within the educational institution, or collaborating with personnel from outside. LEOS as reported earlier allows for informal learning which is student-centered and is driven by personal, sociocultural and physical contexts which help motivate students and has a positive influence on their learning (Falk & Adelman, 2003; Falk & Dierking, 2012; Falk, Randol & Dierking, 2008; Roschelle, 1995). Since collaborative or group learning characterizes informal learning, it is proposed here that the use of LMS could be an effective way of enhancing the learning outcomes in science and this forms the basis of this research.

3.4.4 Section Summary

In summary, the technological landscape of modern e-learning is dominated by so called learning management systems such as Blackboard, WebCT or Moodle. LMS are powerful integrated systems and learning management tools, which support a number of activities performed by teachers and students during e-learning. Teachers can use LMS to develop web-based course notes and quizzes, to communicate with students and to monitor and grade students' progress. Students can use LMS for learning, communication and collaboration. While LMS provides a platform for learning, there are other factors involved to ensure students long term retention of course materials. The three key features for teaching and learning via LMS include creating an environment that establishes social presence, transactional distance and social affordances. These features are most likely to influence student learning outcomes. Section 3.5, which follows, provide the Chapter summary.

3.5 Chapter Summary

The central argument of this chapter has been to make the case that new and different kinds of informal learning are occurring outside of the formal education system and there needs to be a culture shift to accommodate these insights within the formal sector. The literature discusses interactions between students and new emerging technologies such as Collaborative Notebook, CSILE and KGS. The learning models of co-constructing scientific processes such as EC, SKI and LBD helped demonstrate the importance of student-student interactions in many studies. There are benefits reportedly gained from increasing student collaboration and from increasing student autonomy, but the role of the teacher in facilitating the learning environment to promote collaborative learning and to scaffold students' learning is, as might be expected, crucial. LMS provides learning environments which integrate digital resources and new teaching pedagogies to enhance students understanding of science concepts. Blogging/*forum* and *wiki* are a potentially engaging and valued means of communication amoung teens; it seems worthwhile to consider the potential of using these second-generation Web applications in secondary school science classrooms, particularly for informal learning which occurs during LEOS.

CHAPTER FOUR
METHODOLOGY

Overview of the Chapter

This chapter provides a description of the methodology employed in this inquiry. Section 4.1 begins with paradigm, methodology and research design used in science education inquiries. Section 4.2 explains the theoretical framework which guided this inquiry while Section 4.3 outlines the development of the intervention. Section 4.4 discusses the method of data collection; Section 4.5 provides a description of the interview protocol, and Section 4.6 describes data analysis procedures used in this inquiry. Section 4.7 examines measures taken to maintain trustworthiness, and the chapter concludes with Section 4.8 which discusses considerations of ethical issues and negotiation of entry. Section 4.1, which follows, outlines the paradigm, methodology and research design used in science education inquiries.

4.1 Paradigm, Methodology and Research Design

Educational research discovers new knowledge, which assists us to better understand schools and educational institutions, and increases our understanding of teaching and learning and improve curriculum. According to Jaeger (1988), educational research is a *disciplined* inquiry, pursued within an educational paradigm. The theoretical framework or paradigm originally was used by Thomas Kuhn, is also known as a basic set of beliefs that guides action (Cohen et al., 2007, 2011; Denzin & Lincoln, 2011; Mertens. 2010; Neuman, 2011). Anderson and Arsenault (1998) define research as a problem-solving activity, conducted through collection and analysis of primary data in order to describe, explain, generalise and make informed predictions. Paradigms comprise of three components, *Ontology* (how we view the world), *Epistemology* (approaches to gathering knowledge) and *Methodology* (how we collect data).

While Gage (1989) and Schubert (1986) purported that there were three paradigms in education research as discussed in Section 2.1.1, Cohen et al. (2007, 2011) observed that were two called the normative and the interpretive. A key feature in the normative paradigm is the focus on behaviour, which results in responses either to external environment stimuli (e.g., another person), or internal stimuli (e.g., hunger, need to achieve). In addition, the normative paradigm synthesizes general theories from observations that are created by a group of people rather than an individual. An example of a normative paradigm is positivism. In contrast, Cohen et al. (2011) and Glaser and Strauss (1967) argue that the interpretive paradigm takes an anti-positivistic approach and focuses on the individual and seeks to comprehend individual experiences. Thus, in the interpretive paradigm, theories are created from the individuals actions. In other words, theories are developed after research is done, as opposed to the normative where research is based on existing theories. In addition, the interpretive researcher seeks to understand the time and place when an action occurs at a particular setting with the same action replicated at another time and place.

For many years, the positivist paradigm was the paradigm of choice for science education research, chiefly when investigating the relation between different types of instruction and student learning (Cohen et al., 2011; Denzin & Lincoln, 1998, 2011; Filstead, 1979; Jaeger, 1988; Mertens, 2010; Porter, 1988; Rossman & Wilson, 1985). More specifically, the paradigm adopted a quantitative methodological approach which was considered to have merit in particular, for helping provide possible explanations to cause and effect, and that used the power of mathematical analysis to establish general laws and principles (Burns, 1994; Filstead, 1982; Mason, 1993; Neuman, 2011). Studies implementing qualitative methods such as classroom observations, and interviews appeared more frequently in the last 20 years, augmenting science education research and complementing quantitative data (Bell, 1993; Erickson, 2012; Gage, 1989; Hitchcock & Hughes, 1989; Keedy, 1992; Lythcott & Duschl, 1990; Scott & Usher, 2011; Stake 1994).

According to Cohen et al. (2011) and Mertens (2010), educational research uses systematic investigation and application similar to how science is investigated. Research methodology is then an approach that researchers adopt based on their assumptions about reality and the nature of knowledge. In science education, Guba and Lincoln (1989) indicated that methodology is an overall strategy for resolving the complete set of choices or options available to the inquirer, while methods are "the tools and techniques within overall guiding strategies" (p. 158). The term research design means the plans and procedures for research that span the decisions from broad assumptions to detailed methods of data collection and analysis (Creswell, 2003; Creswell & Plano Clark, 2011; Denzin & Lincoln, 2011). The three terms above provide a clear understanding of the words research, methodology and research design.

Educational research can take place at one of the five levels identified by Trochim (2001), as being descriptive, relational, causal, cross-sectional and longitudinal. Descriptive studies attempt to describe what is happening in an educational setting (e.g., classroom, laboratory), and there are two major types of descriptive research; historical which attempts to describe the situation lie in the past and contemporary, which describes the present (Anderson & Arsenault, 1998). Cohen et al. (2007, 2011) call this naturalistic study, and this type of study attempts to develop an understanding of how well students' develop understandings or misunderstandings and ways of interpreting their surroundings. That is it sees human behaviour as diverse and varied as the situations and contexts supporting them (Angrosino & Rosenberg, 2011; Mertens, 2010). The methods of inquiry used include observations and interviews. An example of a descriptive study was conducted by Dahsah and Coll (2007) who described Thai Grade 10 and 11 science students' understanding of stoichiometry. The term naturalistic inquiry is usually used nowadays to describe inquiries that involve individuals in their natural setting (Lincoln & Denzin, 1994; Lincoln & Guba 1985). The main aim is to see what is happening without influence or interference from the researchers' involvement. This is opposite to experimental studies where researchers try to control all variables but one, in order to see the influence of the variable on educational outcomes. Shulman (1988) and Denzin and Lincoln (1994, 2011) point out, that naturalistic inquiry typically uses a variety of data gathering tools, including quantitative tools. The principle difference between a naturalistic and a quantitative approach is that the former recognises the significance of subjective experience, and in general is characterised by greater depth and this forms the basis of this inquiry.

The research paradigm adopted in this study is the interpretive paradigm which considers both social and cultural interactions, important when studying an individual's social behaviour (Anderson & Arsenault, 1998; Guba & Lincoln, 1989; Lincoln, Lynham and Guba, 2011; Mertens, 2010; Neuman, 2011). This study conducted an in-depth inquiry into student experiences of LEOS in a private rural religious secondary school. Hence, an interpretive paradigm allowed the researcher to focus on the details of the educational context and social interactions, therein.

As Lincoln, Lynham and Guba (2011) and Wheatley (1991) state, it is important to make researchers beliefs explicit when designing a method used in an inquiry. While the epistemology which governs this inquiry is constructivism (Duit & Treagust, 1998), there are several variants of constructivism based on the type of research conducted (Bettencourt, 1993; Good et al., 1993; Nussbaum, 1989; Schwandt, 1994; Tobin & Tippins, 1993). This inquiry places stronger emphasis on the social context of learning, and this forms the basis of social constructivism. The notion is that students may enjoy learning more when engaged in socially-mediated learning activities where they have choice and some control over their learning (Griffin, 2004; Scott, 1998). Students were observed in different social contexts such as the classroom, ISI and on Moodle sites such as *forum* and *wiki*.

Case study research provides a research approach which is process oriented, flexible, and adaptable to changing and dynamic circumstances, (Anderson & Arsenault, 1998; Cohen, et al., 2007, 2011). It is also concerned with *how* things happen and *why*. While Stake (1994) stated that case study research is defined by interest in the individual case, Yin (1994, 2009) defines it as an empirical inquiry within a real-life context, with clear boundaries that relies on multiple sources of evidence. Case studies provide analytical rather than statistical generalisations which helps researchers understand other similar cases. Since contexts are unique and dynamic, case studies are useful in reporting the unfolding interaction of events. Sturman (1999) and Yin (1994, 2009) stated that the distinguishing feature of case study is that it enables reporting on the wholeness of the event. Hitchcock and Hughes (1989), Nisbet and Watt (1984) and Neuman (2011) claim that case studies are particularly valuable when researchers have little control over the events; such is the case of this inquiry.

Denzin and Lincoln (2011) state that a case study is a unique example of real people in real situations, which enables readers to understand more clearly how ideas and abstract principles can fit together. Case study research is thus highly data intensive, and strives for a high degree of reliability and validity (see Section 4.6). However, case study does not readily permit generalisations (Anderson & Arsenault, 1998; Denzin & Lincoln, 2011; Yin 1994, 2009). Naturalistic case materials, to some extent, parallel actual experience feeding into the most fundamental processes of awareness and understanding; hence the best case studies are capable of offering some support to alternative interpretations (Cohen et al., 2007, 2011). Readers come to know things told, as if they had experienced them in a narrative form, like storytelling; serving multiple audiences, allowing readers to judge the implication of a study themselves. As a consequence, the findings may be more publicly accessible than other kinds of research reports. Most case study researchers concentrate on describing the present case in sufficient detail so that the reader can make comparisons with their own context (Wolcott, 1988, 1994; Yin 1994, 2009).

There are strengths and limitations involved in the case study approach. The main s*trengths* of the approach are that it allows an in-depth description and analysis of the case in its real life context. Case study research relies on multiple sources of data, employing the methods mentioned above. These methods involve information collected from multiple sources, which provide a deeper understanding of the context and why things are the way they are, increasing reliability (Anderson & Arsenault, 1998; Anderson & Ellenbogen, 2012; Scott & Usher, 2011). Interviews are the prime source of case study data and serve two purposes. First, adding greater depth of understanding to case issues and second, they help identify key informants who are part of the case, helpful for understanding the context. According to Anderson and Arsenault (1998), key informants have inside knowledge which is critical to the case; these individuals can enhance the validity of the conclusions drawn (e.g., in this case, teachers, Head of Faculty). Both direct and participant observation helps enhance understanding of the context by sharing a common experience, and provides insight into interpersonal behaviour, motivation and builds relationships (Stake, 1994, Yin 2009). This approach was used successfully by Mallya, Mensah, Contento, Koch and Barton (2012) in an attempt to understand how we might extend science beyond the classroom, which is similar to this inquiry.

The limitations of conducting a case study are that the researcher is typically faced with a complex issue which requires a comprehensive understanding of the context (Anderson & Arsenault, 1998; Mertens, 2010; Scott & Usher, 2011). A lot depends on the researcher's impressions, because the researcher ultimately defines the study and enters into the 'life space' of the case in such a way that the research becomes an interaction between the researcher and the case (Denzin & Lincoln, 2011; Lincoln & Guba, 1985). Another challenge is that the researcher is required to have the knowledge and ability to collect data using multiple methods and from multiple sources, meaning that they need the capacity to interpret, synthesise and recast information which can affect data reliability. Different case study researchers may tell different stories, so the findings may lack internal validity. As noted above, case study typically lacks external validity because one cannot generalise findings based on one case study. Danger occurs when a commitment to generalise or create theory runs so strong that the researcher's attention is drawn away from features important for understanding the case itself. In terms of the actual methods of interviews and observations, they are at risk of subjectivity for the reasons noted above. Patton (1990), Anderson and Arsenault (1998) note that good interviewing requires considerable skill to avoid bias (e.g., from leading questions seeking to confirm pre-determined ideas not letting the participant's views emerge), and similarly observations may lack reliability and validity because the researcher looks only for what they are interested in and fails to see all relevant activities. Intensive methods like interviews and observations also are relatively expensive because they are time consuming in nature.

This inquiry took the nature of an ethnographic case study (Lincoln & Guba 1985, 1994; Merriam, 1988, Yin 1994, 2009). Case study is defined by interest in individual cases and in this case, the issue is situated in a particular education context (i.e., a private religious rural secondary school). The inquiry seeks to provide insights on how to better plan for LEOS and integrate learning using digital technologies. A qualitative case study approach is characterised by the researcher spending substantial amounts of time in the educational setting; and that was the case here. Hence, multiple interviews and observations were conducted over a considerable length of time (ca. 12 months). Such intensive, ongoing use of qualitative methods was of particular importance in order to gain a better understanding of the current practices involved in LEOS and also to help enhance the learning of science by integrating all three types of learning, namely formal, non-formal and informal using digital technologies. The qualitative methods used in this case study approach are good for investigating issues in depth (Anderson & Arsenault, 1998; Anderson & Ellenbogen, 2012). The methods employed in this inquiry included observation of classroom activities, content and thematic analysis of relevant documentation such as curriculum material and student assessment results, lesson plans and the like; interviews with all stakeholder groups, field notes during out-of-school visits, inspection of student workbooks, postings on *forum* and *wiki*. Next Section 4.2, which follows, presents the theoretical framework of this inquiry.

4.2 Theoretical Framework for the Inquiry

This inquiry is concerned with the learning of science, in particular investigating ways of enhancing students' science learning experiences outside school. This inquiry integrates three types of learning; namely formal, informal and non-formal. This integration included students' learning experience in classrooms and during LEOS, using a learning management system, Moodle, to help enhance the learning outcomes in science. The theoretical basis to this inquiry draws upon the literature reviews provided in Chapters 2 and 3. This framework is based on an analogy derived from plant anatomy, functions and surrounding (see Section 4.3; Figure 4.1). This section begins with a discussion on types of learning (what teachers need to know), followed by learning and LEOS (importance of context). The co-construction of knowledge using emerging technologies is considered next, and the Section concludes by exploring the learning management system which provides affordances for integration of learning. Section 4.2.1, which follows, outlines different types of learning, and what teachers need to know.

4.2.1 Types of Learning: What Teachers Need to Know

As noted in Chapter 2, there are three broad types of learning identified in the literature: *formal, non-formal* and *informal*. While formal learning is more teacher-centred in a highly structured classroom, following a prescribed curriculum, non-formal learning allows for some flexibility and can take place outside the classroom (see Section 2.2.2). Informal learning is characterised by the nature of free choice in learning, and learning that is thus highly learner-centred in nature. Bamberger and Tal (2007) used the phrase *free choice learning* (see Section 2.3.2) to describe informal learning for this reason. Informal learning is characterised by students working in groups and collaborating with each other using a variety of methods. Dori and Tal (2000) state that the goals of informal science education programmes focus on fostering positive attitudes, improving confidence about doing science and encouraging individuals to participate in learning science. LEOS and/or using different forms of communication media particularly web-based media have become a major source of social medium used for informal learning (Ryoo & Linn, 2012; Van Rens et al., 2010).

The literature indicates that teachers who identify LEOS as destinations for education and take their students to an ISI such as a zoo for specific learning goals (Tunnicliffe et al, 1997) need be aware of the psychological needs of students, the key factors of informal learning, and characteristics of a successful informal learning experience (Rosenfeld, 1980; Tal, 2012, Tal & Morag, 2007; Tunnicliffe, 1994). Perry (1992, 1993) identified six psychological needs of museum visitors, all of which must be met for LEOS to be successful in terms of education. It is reasonable to say that these are also important for other ISI visits. The six needs are: (1) curiosity, (2) confidence, (3) challenge, (4) control, (5) play, and (6) communication.

As noted in Chapter 2, the key to deriving the most from LEOS is when learning is facilitated by pre-planning and post-visit activities all linked directly to curriculum objectives (Anderson & Zang, 2003; Rennie & McClafferty, 1995; Tofield et al., 2003), which help give meaning to abstract science ideas studied in the classroom (Anderson et al., 2000; Bolstad, 2001; Orion & Hofstein, 1994). This is consistent with the research findings by other authors who emphasise careful planning in order to avoid learning 'disasters', and to maximise learning especially beyond surface learning of facts (Hooper-Greenhill, 2000; Kisiel, 2003a, 2003b; Nabors, Edwards & Murray, 2009; Sheppard, 2000). Davidson, Passmore and Anderson (2010) state that maximum classroom input equals maximum LEOS gains. This is consistent with earlier findings noted in Chapter 2 where Falk and Dierking (2000) and Gennaro (1981) together with Kisiel (2006a, 2006b) and Sheppard (2000) place emphasis on connections teachers make between LEOS and the curriculum which they say influences cognitive and affective gains.

Students are inherently excited about LEOS but their excitement may inhibit learning. Therefore students' experiences at ISIs need to be focussed by the use of teaching plans. Unfortunately, as stated earlier in Chapter 2, with the exception of a few studies, the literature indicates that most teachers fail to provide proper preparation for their students, and seldom plan these learning activities (Griffin, 1994; Griffin & Symington, 1997; Jarvis & Pell, 2005; Oulton et al., 2004; Tofield et al., 2003; Weelie & Wals, 2002). The literature further reports that children do not necessarily link their classroom based experiences, the curriculum that teachers taught, pre-visit classroom activities, and the educational objectives with ISI visit. There are also reports that little monitoring of learning occurs during visits, leaving students unclear about how the LEOS relates to instruction in the classroom (Anderson, Piscitelli, Weier, Everett & Taylor, 2002; Kisiel, 2003a; Storksdieck, 2001). Therefore, teachers need to engage in planning for LEOS, which considers students' prior knowledge, foci, interactions, and reactions during LEOS and most importantly context in order to more effectively design robust learning activities. Section 4.2.2, which follows, discuss learning, LEOS and the importance of context.

4.2.2 Learning and LEOS: Importance of Context

As noted earlier, learning is seen as inextricably related to the social setting (and this need not be a classroom), a process where students actively participate and create new meanings (Biggs, 1999; Falk & Dierking, 2000; Goodrum 2007; Preston & Rooy, 2007). Learning thus occurs by a process of social interchange (Gergen, 1995; Shotter & Gergen, 1994), and teachers can use LEOS to provide learning for students that cannot be provided within the classroom (Cox-Petersen, Marsh, Kisiel &

Melber, 2003; Kisiel, 2003a, 2006a, 2006b). ISIs such as museums and zoos can be used as experiential learning resources that complement and enrich the school curriculum (Bergseid Ben-Haim, 2006; Kisiel, 2006a; Price & Hein, 1991; Sheppard, 2000).

Moreover, learning in informal contexts has been recommended as an important element in promoting interest in science, motivating student/teacher and student/ student interactions and increasing knowledge (Pedretti, 2002). This is consistent with the literature reported in Chapter 2 where Vygotsky (1986), who shared many of Piaget's assumptions about how children learn, placed stronger emphasis on the social context of learning, which in Vygotsky's 'brand' of constructivism, termed *social constructivism*, emphasized the critical importance of culture and the importance of social context for cognitive development.

A number of authors have stated that the value of LEOS is that it allows and encourages collaborative learning (e.g., Dillon, 2012; Farmer et al., 2007; Gostev & Weiss, 2007; Leinhardt & Crowley, 2002; Rickinson et al., 2004; Rogoff & Lave, 1984; Whittington, 2006). The literature also suggests that context is integral to what we learn, claiming that knowledge is a product of the context in which it is learned (Rogoff & Lave, 1984; Solomon, 1983). Falk and Dierking (2000) defined three contexts which they say influences learning at ISIs: (1) *personal context* which includes the individualised prior knowledge, interest, motivation, expectation and experience the students brings to the ISI; (2) *sociocultural context* which includes the influence of people within and outside the group on learning; and the (3) *physical context* which includes the entire physical learning environment. While learning may happen in different contexts, it is equally important to share these learning experiences, link and integrate with each other to co-construct knowledge. Given its importance, Section 4.2.3, which follows, discuss new emerging technologies and considers how they are reportedly used in co-constructing knowledge.

4.2.3 New Emerging Technologies: Co-constructing Knowledge

As stated earlier in Chapter 3, students have grown up in the digital age and most cannot imagine a world without digital media. This not only facilitates interaction between students, but interaction between students and teachers and experts. The literature on ICT use in education suggests that its use also helps motivate students to learn (Limnious et al., 2008; Rodrigues, 2010). This motivational impact on students' learning helps afford ownership and control with respect to pace of learning, and choice of content (see also Ryoo, & Linn, 2012; Van Rens et al., 2010). ICT integrated learning in science also is reported to help enhance new literacy skills, creativity, social skills and digital competencies (Lewin, 2004; Walsh, 2007). The uses of ICT have reportedly had an impact in the area of science communication and collaboration between students and between students and teachers (Jonasson, 1994; Linn, 2003; Piburn et al., 2005; Tao, 2004).

LMS are software applications that have a number of operational features which are useful for administrative tasks and have affordances for use in classroom practice. LMS are also referred to as 'learning platforms' and combines a range of course or subject management and pedagogical tools to provide a means of designing, building and delivering on-line learning environments. Moodle, an acronym for *Modular Object Oriented Dynamic Learning Environment*, is a free software e-learning platform which is commonly used in secondary and tertiary institutions in New Zealand, including the school used in this inquiry.

The nature of a LMS is consistent with a social constructivist theory of learning, which presupposes that learning is best achieved in social environments and that any form of communication (virtual or real) can be used to enhance the social presence of others and thereby facilitate learning (Anderson, 1995; Downes, 2005; Short et al., 1976; Siemens, 2004a; Wolfe, 2000). A LMS is then a 'pedagogical space' where the teacher and the learner may be geographically separated, but are connected via knowledge construction processes, and who communicate via discussion *forum*, submit assignments via email or digital drop box, within the LMS (Downes, 2005; Howard et al., 2004; Siemens, 2004b). This new type of social space and its social networking features can facilitate numerous types of interactions, whereby student can develop a new sense of 'self' and 'community'; something that can be mediated, negotiated and if necessary continuously renegotiated. Many research studies report that when using interactive materials, students not only learn more, and more quickly and more enjoyably; they learn the much needed life skill of learning how to learn; that is, they begin to take ownership and responsibility for their own learning (Dzuiban et al., 2011; Hartman & Truman-Davis, 2001, Siemens, 2005).

As noted in Chapter 2, social constructivism underpins the research of this thesis. Driscoll (2000) and Wertsch (1991) say that the 'social presence' is a critical component of learning, together with the, 'transactional distance' and social affordance'. LMS is used here as a learning platform, which provides affordances for students to provide evidence-based arguments and explanations and analyse and synthesise data defending conclusions. This is done by co-constructing, *wiki* and /or sharing documents on *forum*, developing NML described above using a LMS, Moodle. Learning can be facilitated in such a way that the perception of social presence is increased by use of a LMS; this in turn greatly increases the ability to substitute ICT for face-to-face interactions while achieving the same learning outcomes (Gunawardena & Zittle, 1997; Richardson & Swan, 2003; Stein & Wanstreet, 2003). Since collaborative or group learning characterizes informal learning, it is proposed here that the use of NML via LMS could be an effective way of enhancing the learning outcomes in science and this forms the basis of this inquiry.

4.2.4 *Section Summary*

In summary, the literature suggests that LEOS provides opportunities for informal learning experiences. Therefore, it is critical that we recognize, understand and learn how to facilitate informal learning as a powerful vehicle for science learning. Although the idea of informal learning is appealing, research shows that meaningful learning is associated with limited choice patterns and effective planning both before and after the visits with strong curriculum links. The integration of LMS with classroom practice and LEOS provides affordances for collaborative and interactive learning; an opportunity for students to take ownership of their learning and become self-directed learners.

Section 4.3, which follows, discuss the development of the intervention for this inquiry.

4.3 Development of the Intervention

This research tries to enhance the learning outcomes in science during LEOS. According to the literature, one of the many ways of achieving this is to ensure that teachers formulate curriculum objectives for these out-of-school visits and integrate LEOS with classroom practices. Learning at ISIs is entwined with the social environment, and studying in small groups provides an optimal context for sharing information and finding answers to complex issues (Falk & Dierking, 2000; Paris, 1997). While it seems that students enjoy learning and engaging in socially mediated learning environments, limited free choice learning helps students to develop natural curiosity with substantial engagement and sound learning outcomes (Bamberger & Tal, 2007; Griffin, 2004). This inquiry integrated student learning experiences using digital technologies, in particular the *wiki* and *forum* features of Moodle. It was reported by the Head of Faculty for Science that the blogging feature of Moodle was disabled because students started to use it as a social networking site. Instead, a similar feature called *forum* was to be used to achieve the same outcomes.

The framework used in this inquiry is based on the analogy of plant anatomy, functions and surrounding (see Figure 4.1). Each component of the framework is detailed next and these form the basis of the intervention used in this inquiry. This intervention was subsequently refined after data collection for the research question one (Chapter 1).

The Section begins with a description of the LMS and its use in integrated learning model. Following this, there is discussion on *wiki* and *forum*, and their potential for integration into teaching and learning. Next, are descriptions of the multi-faceted roles of a teacher, followed by explanations on LEOS and classroom learning. There are also discussions on NML, the learning environment, both real and virtual, and the last part of this Section considers research findings on learning outcomes. The LMS, a learning platform is used as an integrated learning model in Section 4.3.1.

Tane Mahuta: Lord of the Forest

The Tree of Knowledge

Flowers & Fruits

Learning Outcomes

The Atmosphere:

The Learning Environment

Surrounding (Mycorrhizae-Fungi):

Classroom Learning

Learning Outside School

The Trunk:

The Teacher

The Roots:

The Learning Management System (LMS)

Water:

Forum

The Soil:

New Media Literacies (NML)

Nutrients:

Wiki

Figure 4.1: An analogy for the theoretical framework for this inquiry: Based on plant anatomy, functions and surrounding

4.3.1 LMS: Integrated Learning Model

The LMS used in this inquiry was Moodle. Moodle is an acronym for *Modular Object Oriented Dynamic Learning Environment*. This is a free software e-learning platform, also known as a Virtual Learning Environment (VLE). Moodle was originally developed by Martin Dougiamas who help educators create online courses with a focus on interaction and collaborative construction of content, and is in continual evolution. The first version of Moodle was released in August 2002. Moodle can be used in many types of environments especially in education to support a social constructivist epistemology of teaching and learning within Internet-based communities. An analogy with the tree roots (refer to Figure 4.1) is that it helps anchor and support the plant, and this is a useful way to represent the support for learning provided by the LMS.

The stated philosophy of Moodle includes a social constructivist approach to education, emphasizing that students (and not just teachers) contribute to the educational experience. Using these pedagogical principles, Moodle provides an informal, flexible, environment for learning communities. Teachers can use LMS to develop web-based course notes and quizzes, to communicate with students and to monitor performance. A LMS then gives teachers much better opportunities to notice when students are lagging behind. Adaptive collaboration support systems such as creating blended learning environments as mentioned in Chapter 3 can enhance the power of collaborative learning (DeNeui & Dodge, 2006; Swenson & Evans, 2003). Students and teachers can use LMS for learning, communication and collaboration and this forms an integral part of this inquiry.

The focus of this inquiry is to explore the use and perceived value of *wiki* and *forum*, a feature of the Moodle, in high school science classrooms, to enhance the learning of science during LEOS. Also, the intervention seeks to capitalize on students comfort with new information communications technology and how this could be used to support classroom learning. The implications of the findings for future use of *wiki* and *forum* to support problem-based, group-based learning and assessment are considered. Section 4.3.2, which follows, discuss the ways in which *wiki* and *forum* feature in the intervention.

4.3.2 Wiki and Forum

In schools today, many new, unique and powerful technologies are available for teachers to use in support of student learning (Carlson, 2003; Downes, 2004, 2005; MacBride & Leuhmann, 2008; Robertson, 2008). The challenge many teachers face is how to incorporate new technologies into their classrooms in a way that strengthens classroom learning by capitalizing on students' new media literacies. Recently, with the promotion of social software technologies, we have seen the emergence of *wiki* and *forum*. These are new and innovative technological tools which can be used in science classrooms to support student learning by capitalizing on students' interests and familiarity with on-line communication.

This inquiry was intended to support science teachers of Year 11 students in a private religious secondary school and explore issues of intent, use, and perceived value of the use of this technology. This inquiry explored the emerging *wiki* and *forum* affordances which uses the Internet, in particular the LMS (analog = *the roots*) which help in communication, collaboration and co-construction of knowledge in an informal learning environment. An analogy with *water* (*forum*) and *nutrients* (*wiki*) (Figure 4.1) which are essential chemicals for plant growth is a useful way to represent affordances provided for collaborative learning via *wiki* and *forum*. *Forum* was used to encourage social interactions and to develop familiarity with the tool. Data sources in this case included one year's *wiki* and *forum* content, interviews with the facilitating teachers, Head of Faculty, ISI staff and students' perceptions of classroom *wiki* practices. This intervention was intended to do the following: (1) encourage teachers' in creating additional forms of participation and increase student exposure time with content; (2) *wiki* and *forum* were used as pedagogical tools and in ways that likely afforded social benefits; and (3) encouraged both teachers and students to invest more time in communicating through this activity. Section 4.3.3, which follows, discuss the multi-faceted roles of a teacher which feature in the intervention.

4.3.3 Multi-faceted Roles of a Teacher

The Year 11 classroom teachers were asked to create a *forum* site on the LMS, where students could share their thoughts on topical and personal issues on a daily basis. It was intended to be an opportunity for induction to this new pedagogical tool especially for social networking. The teachers were encouraged to make an effort to add to *forum* on a regular (at least daily) basis so that students could see and value the 'presence' of their teacher in their social networks. These teachers were required to write comments to make students feel valued, heard, and create a culture where students willingly shared their daily events with each other. Students who failed to contribute were approached in person to identify what the teacher could do to get them involved. The *wiki* pages were used to introduce students to the topic such as Biology. It was an opportunity to identify student's prior knowledge in this subject area, a key aspect of constructivism. The classroom lessons continued to be used for formal learning, where students used text books and teacher guidance to develop a deeper understanding of this topic. The social networking questions posted on *forum* were:

- Where did you go on the school field trip? What were some features of the trip you did not like? What suggestions can help improve these types of trips;
- How many students have visited an ecological reserve? What is special about this site? Would it be a place you would consider visiting one day, why or why not;
- Share any Māori myths and legends that surround this ecological reserve; and
- If you had the opportunity to create a sanctuary, what are some of the features you would be considering when building it?

Some group learning questions on the *wiki* site *pre-visit* were:

- What is a socio-scientific issue; and
- How do I form a research question from my issue?

Furthermore, the teacher (analog = *the trunk*) played a pivotal role in this integrated learning model, providing a link between the new media literacies (analog = *the soil*) and the learning outcomes (analog = *flowers & fruits*). There are several environments where teachers were involved. There are *four* key areas identified in the literature where the teachers played a crucial role (MacBride & Leuhmann, 2008). First, they created and maintained an interactive learning environment in the classroom, during LEOS and in the digital learning environment. Second, they frequently moderated *wiki* and *forum*. Third, encouraged a high level of student involvement (allowing the students' voice to be the dominant voice in these postings) and finally, being publicly available to afford access to the different ways the *wiki* and *forum* were being used. Before students were taken outside the school, the teachers identified students' prior knowledge through group discussion in the classroom and using *forum* as stated above. Teachers used postings as they were crucial in identifying both, their prior knowledge and gaps in students learning which were used when planning for LEOS. Section 4.3.4, which follows, discuss two contexts for learning: LEOS and the classroom.

4.3.4 Learning During LEOS and in Classrooms

The formal learning in the classroom and non-formal learning during LEOS are important contexts for enhancing learning in science. This is similar to the surrounding of a plant (analog = *Surrounding Mycorrhizae*) whose growth is significantly influenced by other living things (Fungi) surrounding it; the learning environment of science students' is similarly affected by both formal and non-formal learning environments. The literature reports a number of ways by which LEOS can be facilitated. This included the diverse roles of teachers ranging from active mediation between the ISI and the school, and planning and monitoring student behaviour. One of the ways strongly recommended in the literature is for teachers to integrate visits to ISIs with their teaching programmes and use LEOS to complement, not replace, learning activities in classroom. These teachers thus need to look for personal 'hooks' for learning when planning for LEOS (Emmons, 1997; Waite, 2011). For example, from the *forum* posting, the teacher is able to identify those students who are keen about impact of natural events and human actions on a New Zealand ecosystem and have some sound background in the topic of biosecurity. These students acted as student mentors to help co-construct knowledge of other students, during LEOS and during pre- and post-visit discussions using *forum* and *wiki*. Teachers also liaised with the ISI staff at the ecological reserve and indicated the learning objectives, date and time, and preparations students needed to do before they visited the ISI. Section 4.3.5, which follows, discusses the way new media literacies feature in the intervention.

4.3.5 New Media Literacies (NML)

NML is a theoretical framework that has been used to explore the participation opportunities made available through these emerging technologies such as *Web 2.0 Technologies*. NML are used for three key purposes, namely (1) accessibility to a variety to people and resources, (2) connectivity which helps as a social tool to share information and ideas through the webbed structure and finally (3) multiple modalities for expanding the mediating practices which helped construct relationship and knowledge (see Table 3.2 in Chapter 3). NML redefines literacy as not just reading and writing but rather the process of practice of meaning making within social networks (Gee, 2003; Hull & Schultz, 2002; Lankshear & Knobel, 2008; Leuhmann & Frink, 2012).

During the preparatory stage of LEOS, the teacher uploaded a video on the LMS about biosecurity issues for New Zealand. There were graphs, literature articles and other visual representations uploaded on Moodle which students accessed to develop understanding on this topic and discussed these ideas using *wiki*. This phase allowed the development of new media literacies where students took ownership of the questions they pursued and provided evidence-based argumentation and explanations (Linn et al., 1994, MacBride & Leuhmann, 2008; Robertson, 2008; Webb, 2005). NML (analog = *the Soil*) is a useful way to represent the different types of texts, namely graphs and media reports which were provided to students in order to develop skills in intertexuality of information. Information presented in different formats also helps students to develop multiple interpretation skills. This is similar to the different microclimate in the soil which has to be accessed for optimal plant growth. Section 4.3.6, which follows, discuss the different learning environments: Real and virtual.

4.3.6 Learning Environment: Real and Virtual

The teachers are crucial in ensuring that the learning environment they create, either at the ISI, in the classroom or virtually using *wiki* and *forum*, all help enhance the learning of these scientific concepts. The learning environment (analog = *the Atmosphere*) comprising of both abiotic and biotic factors, are a useful way to represent the different types of learning environments, real and virtual provided to students in order to integrate knowledge from different contexts. As the abiotic and biotic factors are crucial in the growth and development of a plant, so are the learning environments which determine the type of learning which takes place. Therefore, the teachers ensured the trip was booked at a time approved by the school and consent letters sent out to inform parents on the purpose of the visit, time, date, and cost involved. The teacher liaised with the ISI staff on the relevant preparation that was done in class before taking them to the ISI.

During the visit, the teacher employed informal strategies to encourage more engagement between students at ISIs (Kisiel, 2006; Tofield et al., 2003). This is reported in the literature as best carried out by probing students' understanding through questioning which helped to find answers to questions, and also assist these students to collaborate with each other (Kisiel, 2006). There were not only worksheets to complete but student had questions which they asked the ISI staff. Again, these questions were posted by students on *forum* and the student mentors assisted in preparing a document which the students used during LEOS and made inquiries with the ISI staff. When this happens, it seems that balancing freedom of choice and scaffolding students' learning, results in meaningful learning outcomes (Mortensen & Smart, 2007; Tal & Morag, 2009). While the *wiki* and *forum* provided opportunities for informal learning which is flexible and voluntary, LEOS provided opportunities for non-formal learning which allowed freedom of choice, not confined to the classroom and the work was organised by the teachers (see Chapter 2). Section 4.3.7, which follows, discuss learning outcomes.

4.3.7 Learning Outcomes

Post-visit discussions are also important to consolidate ideas students had learnt at the ISI. Teachers have to ensure that if students have inquiries to be made with the ISI staff, it is important that these correspondences are facilitated. Learning outcomes (analog = *flowers and fruits*), which is a result of the different physiological processes occurring in the plant, is a useful way to represent the potential outcome of integrated learning model. As stated earlier in Chapter 2, the dialogue between ISI and school helped make lessons more practical and realistic, meaning that science classes were made more authentic. These interactions helped students and teachers to gain information from experts, information on career choices, and made links between science and society, and science and their own lives.

During the post-visit discussions, teachers moderated conferences on *wiki*. It was important for teachers to help co-construct student's ideas by probing their thoughts using inquiry questions. For example, if students had the idea that biosecurity issues only occurred at the borders of the country, than perhaps it was important for teachers to ask why this was so. This was very important since it allowed students to revisit and revise their pre-visit postings as this helped in the development of a better knowledge basis. Teachers at this stage employed teaching strategies which helped develop skills such as elaborating, applying, justifying, relating, evaluating, comparing and contrasting, or analysing before these students completed their research project. It was equally important that teachers included the development of these skills in their formal classroom practice before students were asked to share these practices on *wiki*.

Some of the questions posted on *wiki* post-visit were:

- How do I develop and refine a research question; and
- How do I formulate an opinion based on research and validate a stance taken on an issue?

The students used information they gained from the LEOS, from post-visit classroom discussions and from Moodle activities to complete individual reports (*Learning*

Outcome). The individual report was the summative assessment. The teachers used the marking criteria provided for each achievement standard to grade student performance. The findings were used to critically consider claims made in the literature about the potential of *wiki* and *forum* to effectively support classroom learning (see Appendix A).

4.3.8 Section Summary

In summary, the intervention in this study comprised five steps:

- The teachers prepared and posted responses on *forum* and *wiki* sites and discussed their experiences during informal interviews with the researcher before the visit. The intention here was for the teachers to understand their roles in ensuring a constructivist learning environment;
- Over a period of one term (10 weeks), teachers engaged in interactive posting on the *forum* sites, moderated by the researcher, about what constituted a constructivist based, leaner-centred classroom. This was intended to expand on 1 above, and drive towards a shared understanding of a constructivist learning environment and the teachers' role in such an environment;
- Students engaged in co-construction of a series of learning activities using *wiki*, facilitated and monitored by the teachers. This attempted to draw upon 1 and 2 above, and developed more student-centred activities (i.e., students sharing their experiences);
- Teachers monitored learning activities over a period of one term, where visits were made to the *Show Home* and conducted an evaluation of these activities at the end of the period. The students wrote individual reports which were marked by their teachers. These performance outcomes (assessment results) were used to refine the implementation of the activities before another set of data was collected;
- Scale up of activities across different subject disciplines such as Biology and Astronomy in another term. In this instance, these students were exposed to a similar learning environment but they visited two different ISIs, namely the *Island Ecological Reserve* and an *Observatory*. Assessments were conducted in a similar manner and an evaluation of these results were used for final

evaluation to see if any changes in perceptions had been realised and that students displayed a change in understanding of these scientific concepts.

4.4 Data Collection

This inquiry involved a total of 65 Year 11 (15 Years old) science students and 10 teachers. In New Zealand, Year 11 students are enrolled in their first year of the National Certificate of Educational Achievement (NCEA) programme. The sample consisted of equal number of male and female students and their classroom teachers. The gender mix varied at each phase, with roughly 30 males and 35 females. The choice was made on the assumption that this sample would lead to most understanding of students' learning experiences in out-of-school settings. These students participated in *three* different LEOS. The first visit was made to an ISI called the *Show Home* to explore and report on processes such as convection, conduction and radiation which involved principles studied in Physics, AS 90943 *Design game: Keeping your home warm* (Appendix B). The objective of this LEOS was to help extend student knowledge on concepts relating to thermal insulation and use this to design a house floor plan that is heat/insulation efficient. The second LEOS were a visit to an ISI called *Island Ecological Reserve* to investigate the interdependence of living things (including humans) in an ecosystem, and to explore the impact of natural events and human actions on a New Zealand ecosystem. The visit was part of the Biology programme where students were required to report on biosecurity and biodiversity, AS 90926, *Report on a biological issue: Protecting biodiversity* (Appendix C). The third visit was made to an *Observatory* to explore how the positioning of the three celestial bodies, Earth, Sun and Moon affected the tides and phases of the Moon, AS90954, *Lunar: Our Moon*, (Appendix D). Section 4.4.1, which follows, discuss the procedure used in this study.

4.4.1 Procedure of Inquiry

This research focussed on three NCEA Level 1 Science Achievement Standards namely Physics (AS 90943, Appendix E), Biology (AS 90926, Appendix F), and Astronomy (AS 90954, Appendix G), which were designed to be taught as traditional, face-to-face courses but included various online elements available to students through the Moodle interface. The components available to students included contact information of classroom teacher, access to other students and a list of other websites which could be explored for extending their knowledge. In addition, all documents presented in class were also available online. For example, students could view lesson outlines, hand-outs, group and individual assignments and study tips. Students also received reminders about assignments and exams via the announcement functions (*News Forum*) within Moodle. Though the Moodle site was well integrated into the course and students were encouraged to utilise the *wiki* and *forum* sites throughout the period of this study, it was not a requirement to pass all three standards. Section 4.4.2, which follows, presents the field trip inventory used in this study.

4.4.2 Field Trip Inventory (FTI)

Based on the characteristics of successful informal learning experiences (Anderson & Zang, 2003; Davidson, et al., 2010; Falk & Dierking, 2000; Perry, 1992), the field trip inventory (FTI) was used as a checklist of guiding characteristics which assisted teachers with planning for LEOS. The FTI used three educational terms, 'cognitive, procedural & social' and a number of descriptors which were considered by teachers when developing a successful informal learning experience. The characteristics of successful field trip design are:

Cognitive-Pre-visit Activities: Classroom activities were completed prior to the visit, which were directly related to the visits learning goals. Moreover, the pre-visit activities that were completed in the classroom conveyed a strong correlation between the during-visit and the post-visit tasks. In this inquiry, the first three weeks were used to uncover each of these topics using lecture notes, tutorial discussions and conducting experiments as per unit plan (see Appendices H, I, J). These aimed to provide exposure to a range of scientific theories, models and discussions about the concepts being studied as stated in Chapter 2 (Biggs, 1999; Preston & Rooy; 2007; Goodrum, 2007). Students mainly copied information in their workbook and conducted research in areas which needed to be explored, to explain observations made during experiments. They used textbooks, library resources and other resources already posted on the Moodle site, such as video clips and other relevant literature.

At this stage, an induction session was conducted, which helped provide students with a briefing on how the groups operated, and the use of *wiki* and *forum* were conducted at the commencement of the case study. The importance of considering group dynamics, roles and processes was stressed. The groups used face-to-face classroom sessions primarily to meet, discuss and make progress on issues associated with their assignment. As mentioned earlier in Section 4.2, contributions and editing of the *wiki* and *forum* were done once the meetings and discussions were completed, that is outside classroom time, perhaps at home or even during Study Zone/Homework periods when students are allocated time to use the computer suites. Classroom discussions and postings on *forum* were used by teachers for diagnostic assessment of students' prior knowledge and abilities in the subject area. The most important part of this planning was to group student for LEOS. Each group was made up of eight participants, each characterised by diversity in gender, abilities and experience with NML.

Cognitive-During-visit Activities: The activities completed during LEOS were directly related to the pre-visit activities. In this study, students explored questions which they had put together from their discussions on *forum* and had the opportunity to make inquiries with the ISI staff. To include some free choice in learning, students had the advantage of exploring topics of their own choice which were not assessed. According to the literature reported in Chapter 2, some degree of choice is reported to have better learning outcomes (Falk & Dierking, 2000; Rennie & McClafferty, 1995, 1996).

Cognitive-Post-visit Activities: Classroom activities were used to consolidate learning which occurred during LEOS. There were *wiki* sites for each group, one for each visit (Physics-*Show Home*, Biology-*Island Ecological Reserve*, and Astronomy-*Observatory*) which was used by students for post-visit activities where the groups shared their findings and updated these sites. Members of each group had the opportunity to critique each other's postings. Moreover, the post-visit activities provided the students with an understanding of how the LEOS related to their learning in these informal environments. The post-visit activities were an important aspect of consolidating all components of their learning for these three achievement standards. The postings on *wiki* at the beginning of the course and those written after visiting the

ISIs indicated the depth of learning which had taken place. Students used the *print friendly page* of *wiki* to collate their findings which was used to complete the final report. This report was largely in text form using tables, graphs and diagrams, which was marked and moderated by teachers using the assessment criteria for each standard (see Appendices B, C, and D). Another characteristic of a successful fieldtrip design are procedural aspect, including ISI staff, and advance organisers, which are discussed next.

Procedural-ISI staff: There is evidence to suggest that besides teacher preparation, the other factors which helps facilitate LEOS is ISI staff experience which can impact on students learning experience (Cox-Petersen et al., 2003; Tofield et al., 2003; Tal & Morag, 2007). Students have the desire to interact with the ISI staff because they are viewed as the 'experts'. They are also interested to learn about the career path ISI staffs have taken. Preparation included scheduled meetings with the ISI staff prior to the visit.

Procedural-Advance Organizers: This is a packet of information which provided students, and teachers with a map of the ISI, a description and a directory of the exhibits. It included routes students could take around the ISI. These were also made available to staff and students via the Moodle site. The third characteristic of a successful fieldtrip design is the social aspects which included student groups, control of visit and control of learning, which are discussed next.

Social-Student Groups: Students expect to have fun which often at the same time acts as a stimulus for more detailed learning (Rennie, 2007). Students were grouped with their friends taking into consideration how well they will interact and their ability to work well together. If students do not like their groups, they will less likely interact and experience significant discussions. These groupings were done based on teacher information of student strengths in different areas such as prior knowledge on the topic, ICT skills and leadership.

Social-Control of Visit: Informal learning which includes free choice allows students to take control of their learning. They choose a plan of how they wished to work, with whom and the inquiries they wished to make using advance organisers.

Social-Control of Learning: According to Griffin (2004), students enjoy learning and engaging in socially mediated learning environments where they have both *choice* and *control* of what they are doing (Bamberger & Tal, 2007). While students visited ISIs to collect information in order to complete their internal assessment projects, they were provided with a directory of what they could see and/or do. Students were allowed to choose what they wanted to study and explore their individual interests.

In summary, given that the components of field trip inventory are critical for a successful, effective informal learning experience (Davidson, et al., 2010; Falk & Dierking, 2000; Perry, 1992), it is equally important to consider its components when planning for LEOS which could potentially provide opportunities that reflect real life learning processes. Next, given the importance of collecting qualitative data from different sources, Section 4.5, discuss the interview protocol used in this inquiry.

4.5 Interview Protocol

Interviews are the most common method of data collection in case study method (Anderson & Arsenault, 1998, Yin, 1994, 2009). Effective interview strategies, interview schedules, recording and evaluation of interview data helps provide better insights to the research questions explored. However, the main purpose of the interview is to understand what the students saw as the role of LEOS and if they felt that the use of digital technologies assisted them in enhancing their learning experiences in out-of-school settings.

To do research is to pay close attention and to reflect deliberately on what has been seen and heard. The basic issue is designing strategies for data collections are to think where we would need to be searching, with whom and in what relationships. Addressing such issues is necessary in order to gather evidence to warrant the assertion that one would like to be able to answer the research questions that have been posed in this inquiry. These issues have both intellectual and ethical dimensions (Bogdan & Biklen, 1992; Denzin, 1996; Denzin & Lincoln, 1994; Strauss, 1987; Wolcott, 1994). Good questions are the heart of the inquiry but one cannot anticipate fully in advance the circumstances that will be encountered when the study has begun.

Research questions, data collection operations, and research role relationships necessarily change during the course of a qualitative study. In spite of this, it is important to frame questions in advance and anticipate issues of ethics which are discussed in Section 4.7. This section begins with discussions on interviews which involve both looking and asking questions, followed by types of interviews. Following this, there is discussion on research trends in interview techniques. The last part of this Section considers data collection sources. Section 4.5.1, which follows, discuss collecting data by both looking and asking during interviews.

4.5.1 Interviews: Both Looking and Asking

In qualitative research, there are two primary means of data collection: looking and asking (Erickson, 2012; Lemke, 2012) both of which require consent from all the participants (see Appendix K). Often by looking it is possible to determine what people are doing, but it equally requires asking them via formal or informal interviews. Asking is important because we cannot be everywhere in the present; also it is often more intrusive than watching even when the asking is done very informally. Erickson (2012) notes that the ideal process is a recursive process of observation and interview in which, at each step along the way, insights gained by one method (either by looking or asking) are followed up by using the other method.

Looking and asking in a setting can produce differing sources and kinds of data, each with a distinct epistemological status as evidence; field notes written by the observer, interview comments, machine recording (in this case Livescribe™ technology) and site documentations. An effective data collection design includes many different sources, such observations, interviewing, collection of site documentations and machine recordings. As data analysis (Section 4.6) proceed, if hunches about patterns develop on the basis of field notes, these are cross-checked and confirmed by reference to interview data and site documents, which has a stronger evidentiary claim than if evidence came from only one source. The formal term for this is data triangulation which is necessary in order to draw credible conclusions. Section 4.5.2, which follows, discuss data collection strategies, in particular types of interviews which will be one of the sources of data collected in this inquiry.

4.5.2 Types of Interviews

The interview is the most widely used method of data collection in interpretive research (Anderson & Arsenault, 1998, Yin, 1994, 2009). The chief goal is to ascertain the nature and extent of an individual's knowledge about a particular subject by identifying the relevant conceptions that the individual holds and the relationship among these conceptions. Some of the strengths of using interview as a research method are that it provides opportunities to probe and ask follow up questions, providing more complete information, in contrast to survey questionnaires. There are three types of interview approaches: Structured open-ended interviews, has little flexibility and emphasis is placed on minimising interviewer influence, and so the data analysis is more straightforward. A semi-structured interview is more structured in nature than an informal conversational interview, and involves outlining a set of issues including the use of prompts and pictures that can be explored before interviewing (Rennie & Jarvis, 1995). As an example, this method was used to gain an understanding of primary teachers' and curriculum development officers' perceptions/definitions of technology and technology education in the Solomon Islands (Sade & Coll, 2003).

People are often more easily engaged in an interview compared with completing a questionnaire, although typically the number of participants is lower. Telephone interviews allow researchers to gather information rapidly: An example being public opinion polls (Trochim, 2001, Yin, 2009). Face-to-face interviews, enables the interviewer to pick up non-verbal cues such as facial expressions and variation in tone.

Some limitations of interviews are that they can be time consuming, and resource intensive (Trochim, 2001, Creswell, 2003). While face-to face interviews allow researchers to probe the understanding of an individual participant, the more personal nature of the method can lead to people saying things which are not true, because they want to impress/please the interviewer (Anderson & Arsenault, 1998). Also, it is difficult to record all responses, particularly if the interviewer has to write everything down. Hence, it is often difficult to analyse information in ways which gives clear messages. This is usually addressed by recording and asking participants to validate transcripts. If the questions, procedures and techniques of asking questions are not standardised, the responses are subject to a low level of reliability and validity. Sometimes even the context, which can provide non-verbal cues, can cause disruptions which can affect the type of responses (e.g., noise, interruptions). The trustworthiness of the inquiry is discussed in detail in Section 4.7.

A common characteristic of all three interview approaches is that they are more flexible than questionnaires and allow participants to express their own views and perceptions in their own words, that is, the responses are open-ended, and not confined to a set of predetermined categories. All three types of interview approaches allow the participants to clarify the meaning of any questions they did not understand. In practice, a given inquiry may employ a number of interview approaches, but this inquiry employed semi-structured focus group interviews where a group of eight students were involved at once and a one-on-one informal interview with teachers and ISI staff. Section 4.5.3, which follows, discuss interview techniques.

4.5.3 Interview Techniques

Good interview techniques are important if the researcher intends to collect high quality data. This includes ensuring that the interviews are achieved in a relaxed atmosphere where the interviewee could express thoughts freely and the interviewer saying as little as possible (Bell, Osborne & Tasker, 1985; Erickson, 2012; Lemke, 2012; Posner & Gertzog, 1982; White & Gunstone, 1992, Yin, 2009). However, any response should assist with keeping the conversation moving and being non-judgemental and non-committal. It is imperative to make sure that the pace of discussion is such that the interviewee feels heard and any areas of uncertainty or ambiguity are followed up by the interviewer. According to Creswell (2003), Anderson (1995), and Patton (1990), good interview technique includes good questions which are open-ended and singular (i.e. only one question at a time). One of the fundamental rules in qualitative interviewing is to ask clear, unambiguous questions, avoiding jargon, and terminology that may be unfamiliar to the interviewee. This interview technique was utilised in this inquiry which took cognisance of the translation interface described by Johnson and Gott (1996) in Figure 4.2 given below. Section 4.5.4, which follows, discuss the data collection sources.

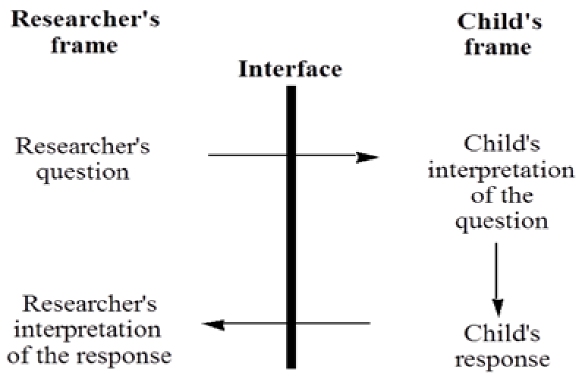

Figure 4.2: The Translation Interface (Johnson & Gott, 1996)

4.5.4 Data Collection Sources

The data collection comprised of three stages. The first stage involved a detailed examination of all the curriculum materials, classroom observations and informal interviews with teachers and students; unit plans, students work book, lesson plans, lecture notes, school LEOS policy and postings on *forum* and *wiki*. The second stage of data collection involved making classroom observations and taking field notes at the ISIs and having semi-structured focus groups interviews with students and with teachers and ISI staff. The third stage also involved semi-structured focus groups interviews with students, and with teachers and ISI staff. Observations were also made of classroom practices after visiting the ISI and further examinations of students' workbooks; assignment reports and *wiki* postings were conducted. Details on classroom observation, student interviews, teacher interviews and other data sources are provided below:

Classroom Observations: Unobtrusive observations were conducted in the Year 11 classrooms at *Rural High School* before and after the visits (see Appendix L). This was done to ascertain what preparations were done before students participated in LEOS, what took place at these ISIs and what activities were conducted after visiting these ISIs. The researcher assumed the role of an 'observer as participant', where her activities were known to the group and her participation in the group was secondary to her role as the information gatherer (Merriam, 1988, Yin, 1994, 2009). The teacher controlled all the activities, and the researcher did not interfere with these practices except in the case of a planned intervention. Data were collected as field notes before, during and after the intervention (i.e., the researcher was present at all three ISIs).

Student Interviews: Student participants were selected on the basis of representative demographics and willingness to participate. An attempt was made to ensure that a reasonable cross-section of cognitive abilities was obtained. All interviews were semi-structured focus group interviews involving eight students from each group. Informal interviews were on-going during the period of inquiry. The content of this interview was aimed at learning about what students expected from LEOS, and probed their views on how LEOS fitted into their classroom activities. Their perceptions of the visit and use of digitally supported learning environment were elicited using post-visit interview protocol (see Appendix L).

Teacher Interviews: The teachers' objectives for LEOS and how they fitted into classroom activities were elicited. Their perceptions of the visits and use of digitally supported learning environment was elicited by a post-visit interview. While semi-structured interviews were conducted before and after these visits, informal interviews were conducted throughout the period of inquiry (see Appendix L). Data from classroom observations and interviews were gathered via field notes employing the Livescribe™ technology, which allowed for unobtrusive audio recording as field notes were captured using a smart pen (see http://store.apple.com/nz/product /H6732ZM/A/livescribe-echo-smartpen).

Other Data Sources: Additional data was gathered from content analysis of topic tests, *forum* and *wiki* postings, and field notes taken at ISIs, informal interviews with teachers during the trips and with ISI staff, curriculum documents and other student work. The data collection was conducted over a period of one year.

4.6 Data Analysis

This inquiry analysed the discourse employing the technique of semantic content analysis (see Section 4.6.2). This consisted of thematic examination of all discourse materials such as transcripts of classroom discourse, small-group dialogues, students' written work, textbook passages, test results, curriculum documents and interactions in online environments. Researchers use these kinds of data to analyse and describe patterns of classroom and small-group interactions, developments and changes in students' use of language and concepts; and similarities and differences between school and community cultures, school science and professional science and mandated curriculum and the delivered curriculum (Cazden, 2001; Christie, 2002; Erickson, 2012; Lemke, 2012; Rymes, 2009).

This section begins with discussion on dimensions of verbal meaning. Following this, there is discussion on three major dimensions of discursive meaning: Semantic content analysis, rhetorical interaction analysis and structural-textural analysis. The last part of this section considers issues of generalizability, interpretive bias, and educational usefulness of discourse analysis methods. Section 4.6.1, which follows, discuss dimensions of verbal meaning.

4.6.1 Dimensions of Verbal Meaning

Language in use creates three interdependent kinds of social and cultural meaning namely presentational, orientational and organizational. That is, it helps construct social relationships among participants and points of view; it creates verbal presentation of events, activities, and relationships other than itself; and it also construes relations of parts to wholes within its own text and between itself and its context. Presentational meaning is most familiar and most studied. This aspect of meaning often is referred to as thematic content (Lemke, 1995, 2012). Orientational meaning, also called interpersonal or attitudinal, constructs our social, evaluative, and affective stance towards the thematic content of our discourse towards real and alternative viewpoints. It includes the language of formality, intimacy, status, power relationships, joking, insulting, and pleading (Lemke, 1998, 2012). Organizational meaning is not perceived always in our culture as meaning, but analysis shows that it is an integral and supportive to both orientational and presentational meaning. This part of thematic analysis tells us how language creates wholes and parts, how it tells us which words goes with which other ones, which phrases and sentences go with which others and how, and generally how a coherent text distinguishes itself from a random sequence of sentences, phrases or words. Section 4.6.2, which follows, discuss three major dimensions on discursive meaning, namely semantic content analysis.

4.6.2 Three Major Dimensions of Discursive Meaning

Semantic Content Analysis: is only possible to the extent that the text repeats the same basic semantic patterns, makes the same basic kinds of connections among the same basic processes and entities again and again. This is also done not only in one discourse event but with many events as undertaken during the inquiry. The common technique of concept mapping is based on our ability to consciously abstract the essential meaning relations amoung key terms in scientific discourse. Discourse analysis can, however, produce the same patterns, and be more semantically explicit about their content, free-from classroom or small group talk, or from written materials of any kind (Lemke, 1990, 1995, 2012). To do thematic analysis properly, it should be done by hand and the researcher needs to be familiar with both the subject matter content and the discourse or text, and with the semantics of at least basic lexical and grammatical relations at the level of study (Halliday, 1985; Hasan, 1984).

Rhetorical Interaction Analysis: All language in use, whether spoken or written, is explicitly or implicitly dialogical; that is, it is addressed to someone and it addresses them, and its own thematic content, from some point of view. It does rhetorical and social work, producing role relationships between author-speaker and reader-hearer, with degrees of formality and intimacy, authority and power, discourse rights and obligations. It creates a world of value orientation, defining what is taken to be true or likely, good or desirable, important or obligatory (Lemke, 2012). According to Lemke (2012) some useful questions to guide rhetorical analysis include: What are these people trying to accomplish here? What are they going to do for one another? How is the talk ratifying or changing their relationships? How is it moving the activity along? What is it assuming about my viewpoint and other viewpoints? How does it situate itself in relation to these other viewpoints? What is its stance towards its own thematic content, regarding its truth or probability, desirability, frequency or usuality, importance, surprisingness, seriousness or necessity? While rhetorical analysis relies on common patterns that emerge, the researcher must also deal with situations unique to the text and these are more ambiguous and subject to different interpretations. Therefore, multiple forms of evidence are needed to support interpretations.

Structural-Textural Analysis: Structural analysis of texts needs to be both ‘top down’ and ‘bottom up’, that is, it needs consistency to reconcile analysis that begin with the smallest unit of meaning and look for how they aggregate together into larger units, with analysis which begins with the largest units and look for how these are composed of functional constituents. Section 4.6.3, which follows, discuss issues of generalizability.

4.6.3 Issues of Generalizability

Discourse analysis studies are often best when they examine a particular community in-depth. Discourse analysis produces its greatest insights when rich contextual information can be factored into the analysis of each text or episode. For this reason, case studies as is in this case are well suited for discourse analysis methods. Here we may learn in great detail about a particular class, seeing repeated patterns within the data and a variety of strategies that create variations on those patterns. However, discourse analysis will not tell us about all classrooms, but it provides us with the tools to analyse and understand more exactly what is going on in any particular discourse or text that we wish to analyse.

However, a common concern in using qualitative methods is the small sample size usually involved and the impossibility of generalising. Patton (1990) writes that qualitative evaluators tend to be “methodically skeptical” of generalisations based on statistical inferences from data collected at one or few points in a program’s life. He further goes on to say that findings based on samples, however, large, are often stripped off their context when generalisations are made, particularly generalisations across time and space. For example, a researcher studying the nature of family problems in the 1980s will not expect the problems to be the same as families experienced in the 1880s. Cronbach (1975) a major figure in educational measurement and evaluation concluded that social phenomena are too variable and context bound to permit very significant empirical generalisations. He suggested that an observer collecting data in a particular situation should take into account factors which are unique to that locale and consider the generalisations as a working hypothesis not a conclusion. Cronbach (1980) is also skeptical that highly specific empirical findings will be meaningful under new conditions. He suggests that instead of design balance, depth and breadth, realism and control, would allow for reasonable extrapolation. This notion was supported by Stake (1994) and Yin (2009) who emphasised on 'particularisations'. Useful understanding is developing a full and thorough knowledge of the particular, recognising it also in a new and foreign context. This knowledge is a form of generalisation which is made by recognising the similarities of objects and issues in and out of context and by assessing the natural covariations of happenings, which could be referred to as transferability; constructivist equivalent to external validity. Section 4.6.4, which follows, discuss interpretive bias.

4.6.4 Interpretive Bias

Discourse data are not only sensitive to the context of immediate task and situation; they also are sensitive to the wider context of cultural norms and assumptions, knowledge, beliefs and values. The analysis of discourse data and their interpretations is itself just more discourse from the point of view of the researcher's community. Therefore, while studies strive for even-handedness and neutrality of interpretation, researchers will project their own values regarding what is better and what is worse onto what were originally mere descriptions of difference. In many other studies even the questions which are asked of the data are asked from a narrow range of human viewpoints.

Discourse analysis is always interpretation and it is just as viewpoint dependent as any other instance of discourse. While different analysts may have different interpretations, the most important thing is that the procedures should be clear enough for others to enter into a discussion on common grounds.

4.6.5 Section Summary

The methods of discourse analysis of verbal data can be used to compare curriculum documents, textbooks, and tests with classroom dialogue, teachers' discourse, student writing etc. They make possible rich descriptions of the lived expression, in relation to official curriculum plans, and to the Web of intertexuality among all the spoken and written language in which education is framed. They also make it possible to analyse how individual students use scientific language and concepts in a variety of situations, and to make this a basis of evaluative assessments. Section 4.7, which follows, discuss trustworthiness of an inquiry.

4.7 Validity and Reliability in Qualitative Research: The Trustworthiness of an Inquiry

This research is based on an interpretive paradigm since it considers both social and cultural interactions which are important when studying an individual's social behavior (Anderson & Arsenault, 1998; Guba & Lincoln, 1989). The interpretive paradigm as Kierkegaard, a Danish philosopher suggested, gives utmost concern to the individual (Refer to Section 4.1 for more details). Traditionally, the quality of a research inquiry within the positivistic paradigm was based on four criteria; internal validity, external validity, reliability and objectivity (Guba & Lincoln, 1989). However, in order to judge the trustworthiness of an interpretive inquiry, Guba and Lincoln (1989) say that *credibility* should replace internal validity, *dependability* replace reliability, *conformability* replace objectivity and *transferability* replace external validity. An in-depth inquiry into the student experience during LEOS was integrated using digital technologies. Hence, an interpretive paradigm allowed focus on the details of the educational context and social interactions. This section begins with discussions on issues of bias and subjectivity followed by discussion on triangulation. Following this, there is discussion on measures taken to maintain trustworthiness of this inquiry. The last part of the Section considers validation of data by peer review. Section 4.7.1, which follows, discuss issues of bias and subjectivity.

4.7.1 Issues of Bias and Subjectivity

Interpretive studies have both advantages and disadvantages. The advantages are its capacity to help researchers understand educational issues in depth. The principle disadvantages are threats to research quality. Denzin (1978) and Guba and Lincoln (1989) stated that interpretive studies are threatened by issues of bias and subjectivity. To enhance quality of interpretive research and address these disadvantages, prolonged engagement allowed the development of good rapport and trust with participants. This helps negate any subjective findings or any misinformation since all participants involved have enough time to offer additional information and confirm individual data.

Guba and Lincoln (1989) noted that progressive subjectivity involves evaluating the researcher's own developing construct. In an interpretive inquiry, alterations in research design are seen as an important part of inquiry, and to maintain dependability, stability of data over time, any changes must be identified and described. Conformability seeks to ensure that the results of the inquiry have not been influenced by the researcher and strict adherence to the method to collect findings which are divorced from 'values, motives, biasness or political persuasions' of the inquirer (Guba & Lincoln, 1989, p. 243). Section 4.7.2, which follows, discuss triangulation, a useful technique to strengthen research rigor.

4.7.2 Triangulation

Triangulation refers to the use of more than one approach to the investigation of a research question in order to enhance confidence in the ensuing findings. Because much social research is founded on the use of a single research method, and as such may suffer from limitations associated with that method or from the specific application of it, triangulation offers the prospect of enhanced confidence. Triangulation is one of the several rationales for multi-method research. That is two or more independent measures are used which greatly reduces interpretation biasness. Patton (1990) agrees with the views expressed by Guba and Lincoln (1989), Janesick (1994) and others (e.g., Altheide & Johnson, 1994; Cohen & Manion, 1989; Merriam, 1988; Stake, 1994) who suggest that triangulation is the most effective means of enhancing the credibility of research findings for naturalistic/interpretive inquiries. Researchers working within a constructionist framework do not deny the potential of triangulation; instead, they depict its utility in terms of adding a sense of richness and complexity to an inquiry. As such, triangulation becomes a device for enhancing the credibility and persuasiveness of a research account (Bell, 1993; Denzin & Lincoln, 1994; Fielding & Fielding, 1986; Mathison, 1988; Shulman, 1988; Welch, 1983; Wolcott, 1988, Yin, 1994, 2009).

Denzin (1978) extended the idea of triangulation beyond its conventional association with research methods and designs. He distinguished four forms of triangulation:
Data triangulation entails gathering data through several sampling strategies so that slices of data at different times and in different social situations, and on a variety of people, are gathered. *Investigator triangulation* refers to the use of more than one researcher in the field to gather and interpret data, especially on large ethnographic inquiries. One function of this type of triangulation is to identify subjective bias that is frequently an issue of concern in naturalistic inquiries (Webb, Campbell, Schwartz & Sechrest, 1966; Welch, 1983, Yin, 2009). However, group dynamics play an important part in successful multiple-investigator inquiries and the different language and/or research perspectives of researchers may lead to conflict during interpretation (Fielding & Fielding, 1986). *Theoretical triangulation* refers to the use of more than one theoretical position in interpreting data, and *Methodological triangulation*, refers to the use of more than one method for gathering data.

The fourth kind of triangulation is the kind that is most related to the process of triangulation in educational research. Denzin (1978) drew a distinction between *within-method* and *between-method* triangulation. The former involves the use of varieties of the same method to investigate a research issue; for example, a self-completion questionnaire might contain two contrasting scales to measure emotional labour. Between methods triangulation involved contrasting research methods, such as a questionnaire and observation. Sometimes, this meaning of triangulation is taken to include the combined use of quantitative research and qualitative research to determine how far they arrive at convergent findings, which means that the two sets of data are mutually confirming.

Triangulation has been used to increase the concurrent validity (Goodwin & Goodwin, 1984), the convergent validity (Cohen et al., 2007, 2011; Jick, 1979) and the construct validity (Cohen et al., 2007, 2011) of the data gathered; to enhance the trustworthiness of the analysis through building up a more credible and coherent narrative (Kiddler & Fine, 1987; Mason, 1993). To reduce bias and limitations of one method, Lincoln and Guba (1985), recommend a combination of methods where the limitations of one can be strengthened by using another method, such as using documents and interviews in this inquiry, to confirm or disconfirm hypothesis. Triangulation using combined different methods of data collection is more preferred over using single instruments. Section 4.7.3, which follows, discuss measures taken to maintain trustworthiness of this inquiry.

4.7.3 Measures Taken to Maintain Trustworthiness of This Inquiry

In this inquiry, credibility was maintained as described in Section 4.7.1. Although interview data were obtained over a comparatively short period of time (12 months), data collection did involve prolonged engagement and persistent inquiry. Prolonged engagement (over two years) helped establish rapport and trust with participants who were relaxed during interviews and spoke freely. To further aid in producing a relaxed atmosphere, almost all interviews were conducted outside classroom hours. Peer debriefing occurred with two disinterested peers; this proved invaluable, enabling the researcher to maintain perspective reducing the likelihood of subjective bias. Negative case analysis also proved beneficial and, for example, each interview was written using the *Live Scribe Pen* and then re-checked for details soon after completion. This process enabled the researcher to continually examine the goal of the inquiry to understand the influence of integrating learning model on students' abilities in enhancing the learning of science. Alterations were made during data collection, mainly during interviews, consistent with the constructivist nature of the inquiry, being dynamic rather than static; this responsive approach has likely improved the credibility of the interview data. Member checks were monitored by participant validation of transcripts, clarifying notes were appropriate, and additional informal interviews with participants to seek clarification where ambiguity in interview transcripts was detected. Field notes were compiled while interviews were in progress and in a number of instances; brief informal interviews were conducted to clarify field notes and statements made during interviews. However, in this inquiry, the researcher continually examined her own stance in relation to the research goals and methodology. The intimate involvement of participants, students', teachers and ISI staff, in all phases of data collection means that this is genuinely a joint inquiry.

Dependability as it relates to those inquiry is determined by an audit trail; that is, the provision of a detailed description of methodology. In a similar manner, confirmability was achieved by the provision of detailed descriptions, in this instance, the data themselves. An appropriate audit trial is provided in the results and discussions presented in Chapters 5, 6 and 7.

Triangulation of the first part of data collection, that is the how teachers currently use LEOS to enhance the understanding of science (see Appendix M) was achieved by examining a wide range of curriculum materials comprising of text books, student work books, unit plans and teachers lesson plans (Teacher Planning Books). These data were further triangulated using informal interviews of teachers. Investigator triangulation involved consultation with teachers, ISI staff and students throughout the inquiry, along with peer debriefing (See Section 4.6.1), served to address the issue of subjective bias. Methodological triangulation involved cross-checking students' views as elicited from interview data and students reports (see Appendices L & T) with the descriptions of learning outcomes produced from the analysis of curriculum materials. Section 4.7.4, which follows, discuss validation of data by peer review.

4.7.4 Validation of Data by Peer Review

Validation of data and the researcher's interpretation of the research findings involved eight peers, four were teachers from the secondary school involved in the inquiry who validated the description of the learning outcomes reported (see Appendix N). Two other individuals were the ISI staff, who provided descriptions on what they believed to be the experiences students needed to have and what was planned between the teachers and them for those visits. Two other individuals, neither of whom were science teachers, but both having secondary teaching background from different departments, acted as disinterested peers and provided regular informal feedback regarding methodology and interpretation of the research findings.

4.8 Ethical Considerations and Negotiation of Entry

Researchers are obliged ethically to anticipate what will be done in data collection, analysis, and reporting, and to explain to those studied why it will be done in that way rather than some other. In order to negotiate entry and deal responsibly with the concerns of those who will be studied, it is necessary to tell them how we plan to conduct the study so that they can consider and give advice about what that will mean to them in convenience and in safety. Without such knowledge, their consent will not be genuinely informed. Written agreements are helpful in specifying the conditions for research (see Appendix K). Section 4.8.1 discusses what the literature has to say about ethical issues, followed by identification and mitigation of ethical issues in Section 4.8.2. Section 4.8.3 discusses confidentiality and anonymity. Section 4.8.1, which follows, discuss ethical issues.

4.8.1 *Ethical Issues*

Anderson and Arsenault (1998) highlight several considerations, which they state must always be addressed if we conducted research in an ethical manner. This is similar to what Anthony, Yore, Coll, Dillon, Chiu, Fakudze, and Wang (2009) identified as fundamental principles of research ethics: *integrity, respect for participants, beneficence,* and *justice.* This research was carried out consistently with Anderson's (1995) guidelines for ethical research.
These were:

- That informed consent had been obtained and appropriately documented and participants were given the right to withdraw from the research at any time;
- That the risks to participants were outweighed by the anticipated benefits of the research;
- That the risks to participants were minimised by research procedures that did not unnecessarily expose subjects to risks;
- That the rights and welfare of the participants were adequately protected; and
- That the research was periodically reviewed.

This research considered general ethical issues as described by authors such as Anderson (1995) as stated above, and also of the particular issues associated with those who engaged in practitioner research (Pritchard, 2002). According to Etherington (2007), this helps make researchers aware of the social and cultural context in which the inquiry is conducted. Within the general principles of research ethics, each national perspective or broader education context, in this case New Zealand has special constitutional considerations, and different communities which must be considered (Anthony et al., 2009). Section 4.8.2 discusses identification and mitigation of ethical issues in education research.

4.8.2 Identification and Mitigation of Ethical Issues in Education Research

Before conducting any research, researchers must gain *informed consent* from all participants; this is what Trochim (2001) calls the principle of *voluntary participation*, and is a key ethical principle of research in education. In simple terms, participants must know what it is they were agreeing to, and what were the potential consequences for them if they chose to participate in an inquiry. This meant that the prospective research participants must be informed about the procedures and risks involved and give their consent to participate. There must be no adverse consequences if they declined to participate in the research or wished to withdraw from the research at any stage. There must be no overt or emotional pressure to comply with researchers demands. Dunnigham (2009, cited in Graue & Walsh, 1998), says a further component of voluntary and informed consent is that the participants understand the research project itself, along with benefits and risks to them, including privacy, confidentiality and what is expected of them.

O'Neill (2010) goes on to say that the principle of fully informed consent should also allow participants to routinely edit their interview transcripts, and provide participants with the opportunity to comment on the analysis of the interview data. This inquiry needed consent from students, teachers, Deputy Principal, and the Head of Faculty of Science and Information & Communication Technology (ICT). This is a private religious school based in rural New Zealand. An invitation was given to all participants informing them what this research was about, how long it would take to collect information for the research problem, and who would be involved in the inquiry. The participants were also informed about the risks involved and possible benefits which may arise from this research. The participants were informed that their participation was voluntary, and that they may withdraw from involvement at any stage of the research.

There were particular challenges for educational researchers when seeking consent from students (Cohen et al., 2007). While some authors insisted the need for parental/carer consent, others took a differentiated approach (Tymchuk, 1992). So some authors say the student may not participate without parental consent and parents may not volunteer without the student's approval, others recommend that Head Teachers could legitimately fulfil the role of ethical guardian of the student in their school as long as the research would have no adverse effects on the student involved (Fine & Sandstrom, 1988; Lindsay, 2000). Whatever stance is taken here, ethical standards required the researcher not to put the participants at risk of harm either physically or psychologically, and engagement with all parties was the most appropriate approach (Erickson, 2012; Jones & Stanley, 2008). Section 4.8.3, which follows, discuss confidentiality and anonymity.

4.8.3 Confidentiality and Anonymity

Two approaches are suggested to mitigate potential harm to participants' and organisations; confidentiality and anonymity. Sometimes even when clear ethical standards exist there is still a need to ensure that researchers consider all relevant ethical issues when formulating a research plan. To address such needs, most institutions have a form of peer review, typified by an institutional or departmental/faculty review board or process (Anthony et. al., 2009; Trochim, 2001). Ethics review committees are typically specific to the discipline (e.g., different for education vs. scientific research). Each research situation generates its own ethical questions and this demands unique and contextual attention on a case by case basis (Pring, 2000). Such committees act then as gatekeepers, and while a concern is the avoidance of controversy and litigation, the committee must have the interests of the participants at heart (Sikes & Piper, 2010).

Interviews together with observation of students' work are the most common methods used in educational research involving students (Cohen et al., 2007, 2011). The data sources in this inquiry were interviews, classroom observations, students' workbooks, curriculum documents, *forum* and *wiki* comments, and other data was gathered as field notes which were used for data triangulation. Interviewing students is more complex than adults. Patton (1990) links an interview to a conversation, but Einarsdóttir (2007) alerts us to the fact that students' may not even know what an interview is, and can have vivid imaginations. This means the researcher has to be cautious if they are to collect reliable data (i.e., they need to be able to filter experience from fantasy). Tofield et al. (2003), for example, report primary school student, when interviewed about previous visits to zoos, claimed they had seen whales and other very large animals, something the researchers thought unlikely. This was triangulated with interviews with the teacher who indicated this was not true. Group interviews may be better with very young students since they can ask questions and talk amongst themselves, helping them feel more relaxed (Graue & Walsh, 1998; Grieg & Taylor, 1999; Mayall, 2000; Tofield et al., 2003).

The primary data source for this inquiry was semi-structured focus group interviews with eight students at a time. The researcher has been particularly mindful of the power relationships between the researcher and participants. Unequal power relationship can impede the involvement of the participants, and lead to the methodological and ethical concerns mentioned above. This inquiry employed semi-structured and informal interviews with teachers, ISI staffs, and the Head of Faculty of Science and ICT. All participation was voluntary and relationships were one of trust and negotiation.

There is a strong relationship between ethics and quality in education research. Waltz (2007), for example, argues that ethical concerns go beyond informed consent and prevention of harm. He suggested that ethical rigour which includes sensitivity, conflict of interest, reputation and embarrassment, should be used as the basic tests of quality in education research. This inquiry also involved a debriefing session with the participants once all data had been collected so that they are informed of the outcomes of the findings. All discussion of findings was aggregated so no individual and their views were identified.

The final stage of data analysis and dissemination involved reflection on the research methodology with consideration for all limitations of the research and a chain of evidence for all decisions made. However, when disseminating research findings, to protect the anonymity of the participants, pseudonyms were used instead of their true names. The findings were presented as aggregated results instead of individual findings. This helped ensure that the readers of this research were not able to identify the participants. However, Waltz (2007) cautions that aggregation of results may adversely affect research quality because important details can be lost in the consolidation of data. It is also important to note that even with these measures the institution itself might still be able to be identified. The school system may be identified but it is less likely that individual school will be. School authorities were thus told that every attempt was made to avoid identification, but made aware of the above issue. At the end of the research, the participants were acknowledged for their cooperation and contribution in a way that confidentiality was still retained.

4.8.4 Section Summary

This inquiry sought to illustrate the ethical issues and concerns faced during this research. But most importantly, indicating ways which were used to address these issues. Section 4.9, which follows, provide the Chapter summary.

4.9 Chapter Summary

As reported earlier, educational research is a *disciplined* inquiry, pursued within an educational paradigm. Paradigms comprise of three components - *Ontology* (how we view the world-*Interpretive*), *Epistemology* (approaches to gathering knowledge-*Social Constructivism*) and *Methodology* (how we collect data-*Case Study*). The materials used in this inquiry were curriculum documents, interviews, field notes, textbooks, classroom observations, tests results, teachers discourse, and student work, written and virtual (*forum* and *wiki*).

The analogy for the theoretical framework for this inquiry is based on plant anatomy, functions and surrounding and the intervention in this study comprised of five steps.

Also, the components of field trip inventory are crucial for a successful, effective informal learning experience which could potentially provide opportunities that reflect real life learning processes. The integration of LMS with classroom practice and LEOS provide affordances for collaborative and interactive learning and opportunities for students to take ownership of their learning and become self-directed learners. Finally to maintain trustworthiness of this inquiry, while ethical issues were considered, all data was triangulated and validated by peer review.

CHAPTER FIVE
RESEARCH FINDINGS: CURRENT PRACTICES AND VIEWS OF LEOS

Overview of the Chapter

This chapter presents the research findings for the first research question, and includes a description of the educational context and background for this inquiry. Section 5.1 begins with a description of the school which helps develop an understanding of the context in which this work was situated, and presents a detailed description of the context of this inquiry. Figure 5.1 displays photographs of some of the learning and recreational facilities present at *Rural High School*. Section 5.2 discusses the provisions for LEOS, and Section 5.3 provides a description of the ISI visited by the school. The Chapter concludes with Section 5.4, which describes the activities carried out, before the site visit, a description of activities done during the site visit, and description of activities done after the site visit.

Figure 5.1 Learning & recreational facilities present at *Rural High School*

5.1 General Description: Setting the Context and Background

5.1.1 Historical Background of Rural High School

The description of the school provided below is derived from document analysis of school promotional material, the staff handbook, the school website, school visits and informal interviews with school staff including the Head of Faculty and science teachers. *Rural High School* is a decile 10[1], co-educational, Year 7-13, day and boarding independent school, set in a large park-like setting of ca. 40 hectares, surrounded by school-owned farmland alongside a large river. *Rural High School* was founded as an independent preparatory school for boy boarders, and opened in February 1936 with a roll of 36 students. The original educational philosophy of "Body, Mind and Spirit", with extension of each student at their level, remains as the ethos and foundation of the independent education offered today. The school motto is *Structa Saxo*, meaning "Built on a Rock" (a biblical reference - Matthew 16:18). The school became the first fully co-educational independent day and boarding school in New Zealand in 1987. During the period of 1988-1995, the school expanded the roll to 500 following the introduction of girls, accompanied by the building of a new science block and additional classrooms. *Rural High School* has housed a Chaplain since 1954.

Although *Rural High School* has a clear and long standing association with the Anglican Church, it is not a Diocesan School, and the Church has no right of nomination or inspection. The Anglican Bishop does, however, appoint the School Chaplain. Likewise, *Rural High School* is independent of the state, and although it receives the normal financial support available to such a school,[2] the control exerted by the Ministry of Education and the New Zealand Qualifications Authority is quite limited. In effect, the only requirements are for public examination prescriptions, and some portions of the Education Act which, by law, apply to all independent schools.

[2] A decile is a 10% grouping, there are 10 deciles and around 10% of schools are in each decile. A school's decile rating indicates the extent to which it draws its students from low socio-economic communities. Decile 1 schools are the 10% of schools with the highest proportion of students from low socio-economic communities, whereas decile 10 schools are the 10% of schools with the lowest proportion of these students. The lower a school's decile rating, the more funding it gets. The increased funding given to lower decile schools is to provide additional resources to support their students' learning needs. A decile does not indicate the overall socio-economic mix of the students attending a school or measure the standard of education delivered at a school. See http://www.minedu.govt.nz/Parents/AllAges/EducationInNZ/SchoolsInNewZealand/SchoolDecileRatings.aspx

The special character of the school includes a focus on Anglican Christian values across the wider curriculum and in "all pursuits and endeavours" (School Handbook). Being an independent school, allows the Trust Board to employ teachers who are not registered with the New Zealand Teacher Registration Board. Such teachers are typically from the Physical Education and ICT Departments. Section 5.1.2, which follows, discuss the governance and management at *Rural High School*.

5.1.2 Governance and Management

Prior to his retirement in 1959, the school was privately owned by the Founder. Upon retirement, the Founder handed over ownership and control completely to the Trustees. The Trust Board meets eight times per year, and receives written reports from the school. The Board sets school policy and delegates responsibility for managing the school to a number of sub-committees. The Trust Board is self-perpetuating, that is, vacancies are filled by resolution of the remaining members. There are two seats for which nominations are invited; the *Alumni* and the *Rural High School Association* (see below). The main objective of the Alumni is to promote and keep alive among the members of the Alumni a continual and active interest in the welfare of their old School. Holders of the Alumni position range from medical doctors, bishops, writers, artists, an All Black (The New Zealand Rugby Union Team) representative, soldiers, diplomats, bankers and politicians. On the other hand, the Association representative is one of the parents with a child currently at the school, being someone who deals with the school, Trust Board and various other groups throughout the school. The Association also has a representative on the school's Uniform Committee. All other Governors retire on a three year rotation, but are eligible for re-election.

The School Management Board delegates authority for day-to-day management to the Principal for all operational matters. In turn, the Principal delegates certain duties and responsibilities to senior colleagues, including the Business Manager, who acts as Secretary to the Board, and is responsible for wider administration. Other senior staff includes the Property Manager and the Communications Manager, the latter who coordinates marketing and promotion of the School. The Board provides oversight and governance of the school and appoints the Principal and the Business Manager.

From January 1996 to 2014, the roll doubled to more than 1,000 students at the time of the inquiry, with 100 academic staff, and an impressive building programme including new boarding houses, new faculty blocks, and tennis, equestrian and golf academies, Student Services Centre, the Sports Centre and a new Library. The School Master Plan has resulted in all new buildings following the Lippincott architectural style, with coordinated colours. The school's gardens and grounds have been developed and enhanced with an annual tree planting programme. The school's environmental groups have made a significant contribution to the school's Enviroschool status.[3] One of the main objectives of an Enviroschool is to educate students about creating an environment that is more vibrant and healthy than the current environment; and is intended to feel like a living ecosystem that can support the community towards sustainability.

Rural High School has thus entered the 21st century with an expanding campus, record roll in the 1000s, modern facilities, and a strong sense of purpose and confidence. It is a leading independent, fully co-educational school. The school attracts students from the Waikato, King Country, and Taupo areas, along with the Eastern Bay of Plenty, Tauranga and as far north as Auckland and Whangarei. The school has a balance of students from town and country origins, and a number of full-fee paying international students from Pacific-rim countries, the Pacific Islands, and South East Asia. *Rural High School* is committed to "developing students, who come with a positive attitude, so they can reach their full potential in body, mind and spirit, in a safe and caring environment" (School Handbook). Next, Section 5.1.3 describes the faculty structure and curriculum statement.

5.1.3 Faculty Structure and Curriculum Statement

The faculty structure is the main vehicle used to drive curriculum development, staff professional development, administrative and support staff at the school. Through the Deputy Principal (Human Resources), staff are informed of opportunities for professional development through polytechnics, Universities and other providers.

[3] An Enviroschool is a school which provides a particular programme which helps students go on a unique sustainability journey through exploration and discovery, where they develop learning and language, care and creativity, relationships and responsibilities suited to their developmental stage. What emerges is a connection with nature and a sense of belonging to the environment and community. http://www.enviroschools.org.nz/enviroschools-programme

Rural High School offers a curriculum from Years 7 to 13, and their promotional material states that they aim "to challenge all students in preparing them for life in the wider community of New Zealand and the world" (School Handbook). The school handbook stipulates the curriculum to be "dynamic, innovative, broad, holistic, inclusive, flexible and relevant." The school reviews the curriculum documents annually in order to best meet the changing needs of students and the educational environment. The Head of Faculty (HoF) reported during informal interviews that this year saw a large increase in the number of science students at Year 11 (ca. 15 years old), which caused a shortage of teaching staff. The Department planned to conduct night classes from 6.30pm to 8.00pm to cater for these students.

The New Zealand Curriculum provides the major structure for the subjects offered (Ministry of Education [MoE], 2007). The school also provides curricula offered by International Baccalaureate, the University of Cambridge and Industrial Training Organizations, so as to "best challenge and meet the needs of students" (School Handbook). The academic curriculum includes: English Language, Other Languages, Mathematics, Social Sciences, Sciences, Technologies, Performing Arts, Physical Education, Health and Outdoor Education. The cultural curriculum includes: Debating, Performance Drama, Performance Dance, Performance Music, Musical Choral and Speech and Drama tuition, Stage Challenge, Theatre Sports, School Productions, Concerts, Art exhibitions and Wearable Art. The sports curriculum includes most New Zealand individual and team sports, including academies in Tennis, Golf, Equestrian and Rowing.

The learning environment of *Rural High School* includes styles and practices which are intended to "maximize dynamic innovative learning and the pursuit of excellence" (School Handbook). Information in the School Handbook suggests that the school strives to create an environment that "caters for student individuality in a thinking culture, so that each student has the opportunity to maximize their potential" (School Handbook & Hof Interview, 21 October, 2013). As noted above, the school also owns a 200 hectare dairy farm which grazes about 500 cows. This facility provides significant learning opportunities for agriculture students, and a number of students go on to study tertiary education programmes in this discipline.

Formal qualifications offered at the school include those offered on the New Zealand National Qualification Framework (NQF), that is, the National Certificate of Educational Achievement (NCEA) at Levels 1, 2, and 3, the New Zealand Scholarship, Industrial Training Organization Standards, the International Baccalaureate Diploma, the Cambridge International Examinations in Mathematics, and other examinations as chosen from time to time to challenge and meet the needs of students (School Handbook).

The school says students are encouraged to "strive for excellence in all curricula and extracurricular areas," and the school is proud of student achievement in academic, cultural, sporting, interpersonal, spiritual, leadership and citizenship fields (School Handbook). The school evaluates and reviews its programmes annually through student, parent/caregiver, and staff and Trust Board feedback. These reviews are held with the aim of improving and refining goals, content, delivery, structure and outcomes of the curriculum, in relation to student achievement (HoF Interview, 21 October, 2013). Given its importance, Section 5.1.4 discusses the schemes of work.

5.1.4 Schemes of Work

The classroom and other learning activities are specified in what the school refers to as a "Scheme of Work" (School Handbook). A Scheme of Work sets out the texts to be used, references required and, if appropriate, the practical or out-of-class activities. Schemes of work are typed up and made available to teachers concerned (see Appendix I) for an example of a Scheme of Work for Biology 1.2. This is also referred to as the Unit Plan AS90926 with a school file copy deposited in the Principal's office. While the curriculum is subject-orientated, there are obvious areas of inter-subject liaison and commonality of interest. This sometimes results in overlap and cooperation in the writing of schemes. While according to the HoF, moves towards "an integrated curriculum approach is encouraged" (HoF Interview, 10 March, 2014), examination of the schemes of work/unit plans as well as interviews with science teachers indicated little evidence of this happening (see Appendices H, I, J), and the same could be said for the Unit Plan for Year 10 Ecology study (see Appendix O). For assessment against standards, the schemes must work within the policies of *Rural High School* for administering NCEA. For example Science 1.4, AS

90943 standard is taught and assessed according to the marking criteria (see Appendix B). This will be further discussed in Chapter 6. It is the duty of each HoF or Teacher-in-Charge (TiC) to keep his/her Unit Plans up to date. It is interesting to note the presence of a Professional Leaning Communities (PLC) within this school, which focuses on working interdependently to achieve "a common goal for which members are mutually accountable" (School Handbook). Informal interviews with the HoF indicated that this consists of 40 minute meetings routinely scheduled on Friday mornings, where the members discuss issues and formulate goals and strategies of achieving them as a team (HoF Interview, 12 February, 2014). These issues range from curriculum documents, schemes of work, student achievement, sports, faculty meetings and e-learning. The focus of PLC at the time of the inquiry was to help students become 'self-managers', with a strong emphasis on the use of the student diaries to be used for weekly goal setting.

The *Rural High School* Staff Handbook places strong emphasis on homework, which is referred to as 'prep time'. The prep time is provided within the school day where students report to either the computer suites or school library for independent study. According to the School Handbook, the purpose of setting prep time is to enable students to consolidate the work they have covered in class, to practise the skills they have learned in class, and to arrive at a more complete understanding of the topics introduced in class, to prepare, by reading, for forthcoming topics. The HoF viewed prep time as an integral part of each teacher's lesson plan. According to her, the assignments set should be carefully thought out in advance, not "hastily decided in the last minute or two of a lesson" (HoF Interview, 04 December, 2013). The school also encouraged regular, daily assignments of prep and places emphasis on exercises that require students to 'think' (HoF Interview, 04 December, 2013).

5.1.5 E-Learning at Rural High School

The Staff Handbook stipulated that e-learning formed an integral part of *Rural High School's* community. Interviews with the senior teachers indicated that all students were expected to use the tools available to them to enhance their learning and achievement (HoF, TiC-Chemistry, Biology, Physics, Science, Interviews, 10 March, 2014). All teachers felt that Moodle could be used as an effective teaching pedagogy for students who were not on site as they were either visiting other countries on sports programs, on excursions, or away sick. As a consequence, the school allowed students at all year levels to bring personal digital devices to school. A ‘device’ here could be a laptop, tablet, netbook, iPad or any Internet capable device thought to assist learning. This initiative by the school was referred to as BYOD (Bring Your Own Device, HoF, 10 March, 2014). The rationale behind allowing students to bring their own devices was that they were familiar with their own devices, and could connect them to the school’s wireless network independently, and thereby gain access to Moodle, school webmail and their personal ‘drive’. While this sounded reasonable, interviews with students and classroom observations made on 22 October 2013 suggested that there were in fact very few devices that the Year 11 students who were involved in this inquiry brought to school. Students said they had “difficulty accessing the computer suite due to over booking” (Student Interview, 04 December 2013). The Year 11 students, however, said they had computers at home, which they used for completing tasks requiring digital devices (Student Interview, 04 December, 2013). The Principal’s report in the School Handbook suggested that Internet connected devices were considered an important 21st century learning tool, as “they engage students to make connections, overcome barriers of time and distance, facilitate shared learning communities and open up new and different ways of learning which is consistent with the New Zealand curriculum, International Baccalaureate curriculum and the Cambridge curriculum” (School Handbook). The teachers were encouraged to use a range of ways to facilitate learning via ICT, such as curriculum design, lesson plans, graphic organisers, formative and summative assessment too. The school believed that a blended learning environment would help improve student performance beyond what they could accomplish through conventional teaching methods (HoF Interview, 12 February, 2014).

During informal interviews, the students seemed to share the School’s vision of using digital technologies to aid learning. The students in Year 11 were about 15 years old and most came from fairly wealthy middle class families. Being a decile 10 private secondary school, tuition and boarding fees were high, meaning this was a school in a high socio-economic area (ca. NZ$20,000 for day scholars, and NZ$30,000 for borders pa). While a school teaching day ran from 8.15am to 3.30pm, most of the boarding students started early with, for example, rowing programmes supervised by their Physical Education teacher at a nearby lake, followed by rugby practice before breakfast, and the first lesson started at 8.15am. The students interviewed for this study were selected by the HoF mainly because they were deemed academically competent with well-developed ICT and teamwork skills. Section 5.2, which follows, describes the different types of LEOS conducted at *Rural High School*.

5.2 Provision for LEOS at *Rural High School*

During informal interviews the HoF of Science at *Rural High School* stated that she strongly believed in taking education outside the school (HoF Interview, 21 October, 2013). However, examination of the Faculty calendar for the year the inquiry was conducted showed considerable differences in the number of LEOS activities between the junior (Year 9 & 10) and senior classes (Year 11, 12 & 13). Interviews with teachers and the HoF suggested that this was because the classes at senior levels were so large, that more teachers were required and that the cost for meals and transportation was deemed unaffordable (HoF Interview, 12 February, 2014). An additional inhibiting factor was lack of flexibility in the teaching calendar, meaning senior students had to prepare for national examinations at the end of the year. As a consequence, in reality few, if any, outdoor learning experiences in science subjects were provided for the senior students. An additional complication was a requirement that students complete the tasks they would miss out on if they went on a fieldtrip, hence any trips needed to be organised for the end of the year when all teaching had been concluded, and students could do tasks which did not require formal assessment (Science Teacher Interviews 04 December, 2013).

Inspection of the Science Faculty calendar indicated that the ISIs visited by students included Rural Research Station (a pseudonym for a Government funded science research centre), the Hamilton Zoo, Maungatautari Ecological Reserve (a private ecological trust consisting of a mountain fully pest-proofed in which endangered species such as the Brown Spotted Kiwi were re-introduced), Mount Pirongia, Lake Taupo and Tiritiri Matangi Open Bird Sanctuary (similar to Maungatautari Ecological Reserve, an island sanctuary for endangered birds). Informal interviews with teachers indicated that while some of these ISIs provided education officers or other staff to facilitate learning, most of the visits were managed by the teachers themselves (HoF Interview, 06 February, 2014). Ms. Harris (a pseudonym), the HoF, for example, was surprised to realise during our discussions that there was no LEOS provided for the senior chemistry and physics students in the year of the inquiry. She said “I find it hard to believe, and did not realise that there were no fieldtrips for the senior students.” This was further compounded by the fact that the school had no official document or policy on LEOS except for the Risk Analysis and Management Systems Forms, RAMS (see Appendix P). The school, however, was officially supportive of outdoor learning experiences, provided the teachers did all preparation and organization needed. Section 5.3 below describes the ISI visited by this school.

5.3 Description of the ISI Visited by *Rural High School*: *Island Ecological Reserve*

5.3.1 Background of Island Ecological Reserve

Examination of the ISI documentation and website indicated that the *Island Ecological Reserve* Restoration Project encompassed a large area of mixed broadleaf/podocarp forest on a mountain in the central region of New Zealand’s North Island. The forest comprised a diversity of habitats that could be divided into nine vegetation association zones. Some timber extraction occurred on the lower slopes in early European settlement times, but much old-growth forest remained. The forested mountain (which has a ‘mountain’ of maximum altitude 797 m) had been fenced around its base with a 47 km long fence, with the installation completed in 2006. Most exotic mammalian species had been eradicated within this boundary. Continuing management aimed at removing those that remain, such as the European rabbit *Oryctolagus cuniculus*, brown hare *Lepus europaeus* and house mouse *Mus musculus* (Ewen, Parker, Richardson, Armstrong, & Smuts-Kennedy, 2011). There were approximately 260 km of pest monitoring lines (with more than 3,000 tracking tunnels) within the reserve for mammal pest detection purposes. The Project aimed to permanently eliminate all introduced mammals, and to restore the forest with a healthy diversity of indigenous plants and animals. In a discussion with the ISI staff, they said that endemic bird species such as Hihi, Brown Kiwi, North Island Kaka, Whitehead and Yellow Crowned Kakariki had been introduced in this area (ISI Staff Interview, 02 December 2013). Mr. Linc (a pseudonym), one of the ISI staff stated that he was very pleased to report that the successful reintroduction of Hihi would complete the establishment of an avian nectivore (eat sugar–rich nectar produced by flowering plants) guild, as the two other extant endemic nectivorous species (eat insects or worms), Tui and Bellbird/Korimako were already present (Ewen et al., 2011). *Island Ecological Reserve* was surrounded by pasture land used predominantly for dairy production. As this farmland habitat represented a hostile environment affording little or no suitable habitat and also predation to these native bird species, it was hoped that this would generate an 'island effect' preventing these birds from dispersing from the protected reserve forest (ISI Staff Interview, 02 December, 2013). *Island Ecological Reserve* had also received 60 *Tuatara* as a *Taonga* with 40 being released on the main mountain and 20 in the Tuatarium, an enclosed area which was visited by students and ISI staff. *Taonga* are things, including wildlife, which are deemed by Māori as a 'treasure', and they have significant cultural importance (ISI Staff Interview, 02 December, 2013).

The description of the ISI funding source provided below is derived from document analysis of the promotional material, website and informal interviews with ISI staff. The Ecological Island Trust received grants, donations, products and support from a range of individuals, companies and organisations (ISI Staff Interview, 02 December, 2013). The Ecological Island Trust was dependent upon the sponsorship of central and local government, major corporate and philanthropic organisations for the ongoing improvement, maintenance and operation of this world class ecological restoration project (Ecological Island Trust website). Some of the major sponsors continuing to support the work of the trust included: Ballance Agri-Nutrients, BNZ Save the Kiwi Trust, Department of Conservation, Environment Waikato, Fonterra, Lion Foundation, Mighty River Power, Transpower, Trust Waikato and Waipa District Council. While the founding sponsors for the restoration project were Mighty River Power and the Scottwood Trust, gratitude was expressed to the Charitable Trust for grants to encourage environmental awareness in different age groups.

5.3.2 Island Ecological Reserve: An Informal Science Institution

While *Island Ecological Reserve* provided a home for nationally endangered bird species such Kiwi, Kokopu, Kaka, Hihi, Kakariki, Robin and Popokatea, it also seek to provide hands-on learning experiences for people of all age groups (Ecological Island Trust website). The ISI staff referred to the mountain as the 'maunga' which meant classroom with the mountain; then seen as a place where teachers or staff can provide a variety of enriched learning opportunities. The aims of the establishment were to enable students to:

- Experience the rich history of the *maunga* and its unique and ever-changing biodiversity;
- Discover how two significant conservation technologies (pest proof fencing and pest eradication) have enabled the ecological restoration of the *maunga*; and
- Understand the important role people have as *kaitiaki* or guardians of the land (ISI Staff Interview, 02 December, 2013).

Education programmes offered by the ISI are provided for all age groups. The programme times are usually from 10.00am until 2.00pm to coincide with school hours. The programmes were only available on Tuesdays, Wednesdays and Thursdays, and the activities are intended to provide opportunities for students to explore authentic contexts for learning with key themes such as Biodiversity, Interdependence, Sustainability and Personal and Social Responsibility. There was only one permanent ISI staff (Mr. Linc, a pseudonym) who seemed hesitant to share about his background during an interview, but said that he was part of the trust; that he was "one of NZs most experienced outside the classroom teachers" (email, 26 November, 2013). It was Mr. Linc who presented an hour long introductory speech when the students first arrived at the ISI. Two other males present during the visit were employed as temporary staff, and acted as guides. They appeared to have profound knowledge about the local area and the restoration project. One of the guides said that he was completing his Master's programme at a local University (ISI Staff Interview, 02 December, 2013).

Informal interviews with science teachers after the visit to the ISI suggested that all arrangements for the trip were conducted by the Teacher-in-Charge (TiC) who liaised with the Deputy Principal to arrange transport and meals. Teachers did not have any input in the organisation of the trip but were responsible for student supervision at the ISI, and collection of permission slips (Science Teacher Interviews, 10 December, 2013). Interviews with the TiC, Mr Macdonald (a pseudonym), indicated that this was a trip they had been on several times in the recent years, implying that the ISI staff knew what was expected by the school.

He went on to say that during the planning stage, he informed ISI staff about the activities he had planned to do at the site. However, he was surprised to find that some of the things he had asked for did not happen. While Mr. Macdonald thought that the ISI staff had planned the visit relatively well, the HoF, Ms. Harris thought otherwise. She indicated that she was not impressed with the way all bookings were handled, and the overly long introductory speech (HoF Interview, 10 March, 2014). Observations and interviews with the science teachers, in particular Mr. Macdonald, indicated that the ISI provided a generic programme where students and staff arrived at 10.00am at the hall where they were greeted and told about the activities of the day. After an hour long introduction by the ISI staff, students had an early lunch, and at 11.00am the 102 students were divided into three groups. Mr. Linc and two other guides then led students on a tour around the reserve. The activities ended at 2.00pm when the students boarded the buses to leave for school (TiC Interview, 10 March, 2014). Section 5.4 below describes the activities carried out before, during and after the site visit.

5.4 Description of Activities Carried Out, Before, During and After Visiting *Island Ecological Reserve*

5.4.1 Pre-visit Activities Carried out at Rural High School

Before the visit, a meeting with HoF confirmed that the trip to *Island Ecological Reserve* was scheduled for Monday 02 December, 2013 (HoF Interview, 26 November, 2013). It was interesting to note that due to booking issues, the students (204) had to be regrouped into two groups (102 each) and were visiting the site on two different days. Additionally, the teachers who were teaching these topics in the classroom were not necessarily those accompanying the students on these visits. A week before the trip to the ISI, students went on camping trips, and as a consequence there were no discussions in classroom about the purpose of the visit. Examination of the student consent letter indicated that it did not provide any detail of the activities planned for the day at the ISI. The trip was scheduled in the last week of the school year and the students in the second group were only allowed one day to complete their final reports. The HoF stated that she thought most of the work on pest eradication should have been completed long before the trip was planned, according to the Unit Plan. However, interviews with teachers showed that different amount of work was covered by the different teachers (Science Teacher Interviews, 04 December, 2013).

The Year 10 science teachers used a number of resources, namely, websites, newspaper articles, text books, and other resources to develop some fundamental knowledge on the topic of Pest Ecology before the visit. Some of the concepts they reported covered in the classroom before the visit were ecological niche, pest eradication and monitoring, food chains and food webs, producers and consumers, flow of energy, predator-prey relationships and influence of humans on population of endangered species (Science Teacher Interviews, 04 December, 2013). The students were required to complete a project at school titled '*Pest Ecology-Investigating the Rat Population in the Rural High School's Community and Pest Impacts on Island Ecological Reserve*' which required LEOS (see Appendix Q). The students informed that prior to the visit, they answered 20 questions, using website (Student Interview, 04 December, 2013). While the student instruction sheet reported that the data collection from the tracking tunnels were to be done once a week for half a term, interviews with teachers revealed that this did not in fact occur (Science Teacher Interviews, 04 December, 2013). Instead, the students conducted this survey in three hours over a week. The teachers' and students prepared seven tracking tunnels for monitoring the pest population around the school vicinity. These tunnels were made of cardboard covered with black sticky paint smeared with peanut butter, and placed near different buildings around the school. The intention was that the pest would be attracted by the peanut butter, and evidence of their presence would be footprints left on the paint. An example of such a trap, including the footprints, is provided in Figure 5.2 given below.

Figure 5.2: Samples of pest traps used at *Rural High School* to monitor rat population before the ISI visit

Students in Year 10 studied a topic on Pest Ecology where they worked in groups and collected data from the tracking tunnels (pre-designed boards with peanut butter and black ink) which were set up around their school. The pests which were expected to visit these sites were feral cats, rats, stoats and ferrets. The data were to be collected from each class and pooled, and subsequently used by students to write their interim reports. It was intended then that visiting the *Island Ecological Reserve* would provide students with an insight to what was being done on a larger scale to control pest populations. Teacher planning suggested that LEOS should complement classroom teaching because the students were asked to use the data collected from the ISI to complete their final report on this topic. It was interesting to note that all interaction between the ISI and the school were conducted via the TiC, without involving other Year 10 teachers. This was reported to be the usual practice at *Rural High School* (Science Teacher Interviews, 10 December, 2013).

The tracking tunnels were left out for two weeks, collected and the footprints studied to identify the pest population around the school. The teachers were rather unhappy when this revealed only cat foot prints, and they felt this could not be used as evidence towards completion of this project. The reason given was that the project was on investigating the rat population in the *Rural High School* community (Science Teachers Interview, 10 December, 2013). Mr. Macdonald then asked the teachers to use data collected from previous year for this project. Only 1 out of the 10 teachers interviewed said she managed to complete the project and provided some assessment feedback, while other teachers said they did not get enough time to do this (Science Teachers Interview, 04 December, 2013).

5.4.2 Activities Carried out at Island Ecological Reserve

On December 02, 2013 at around 09.00am, 102 students and 10 teachers arrived in four different buses from their school. They arrived at a community hall in a small nearby rural town called Fuafua. The students looked tired and observations indicated that they were mostly discussing their recent camping trips, held the day before. The teachers guided the students into the community hall where they were all asked to sit quietly and wait for the introductory presentation by the ISI staff. Interviews with the students later during the day suggested that they were not informed about anything that was happening on the day other than that they were visiting this site which was described as pest-free (Student Interviews, 02 December, 2013). At around 9.30, Mr. Linc arrived carrying a data projector and a stand; he hurried through the main entrance of the community hall and called for everyone's attention. He was accompanied by two other ISI staff namely Jeff and Jim (pseudonyms) who helped set up the equipment and displayed a number of traps and stuffed animals on the hall stage and then took a seat on the side of the hall facing the stage. Mr. Linc introduced himself as the Education Officer, and said he was a member of the Ecological Island Trust. He then provided a 45 minutes introductory speech on the ecological reserve as illustrated in Figure 5.3 given below.

Figure 5.3: An introductory presentation on the history and involvement of the Island Ecological Trust in looking after the *Island Ecological Reserve*

At the conclusion of his presentation, the teachers asked the students to have an early lunch before they were taken on a guided walk for two hours. The students were then asked to board the buses again, and were taken to the entrance of the 47km fenced area. Here, the teachers asked the students to divide themselves into different groups, and each group was guided by one ISI staff with about 35 students in each group.

During the visit, it was difficult to see much interaction between students on the topic under study. Additionally, the teachers played a largely passive role while on the site (Field Notes, ISI Visit, 02 December, 2013). The ISI staff asked all questions, but seldom allowed students any opportunities to make inquiries during demonstrations (Field Notes, ISI Visit, 02 December, 2013). The introductory session by Mr. Linc was considered by some of the students to be “impressive”, especially the slides showing maps of the *Island Ecological Reserve* and the different types of traps which were new to them (Student Interviews, 02 & 04 December 2013). However, most students reported that it was "boring and mainly for a younger audience" (Student Interviews, 02 & 04 December, 2013). These students said they enjoyed seeing *Takahe* and *Tuatara* (see Figure 5.4), and visiting the tower to see the top of the trees (Student Interviews, 02 & 04 December, 2013). But as noted above, the students were given very limited opportunity to make inquiries during the introductory presentation as well as during the guided walk (Field Notes, ISI Visit 02 December, 2013).

Figure 5.4: Students on a guided tour around the *Island Ecological Reserve* – bottom right a native reptile, *Tuatara*

5.4.3 Activities Carried out After Visiting the Island Ecological Reserve

The students reported that experiences during their ISI visit allowed them to develop a better understanding of the science taught in the classrooms which they could relate to everyday experiences around them. Furthermore, they felt that the learning at ISIs helped improve their attitude to school science and interest in further learning - "I actually saw a *Tuatara*" (Student Interviews, 02 & 04 December, 2013). Another group of students decided to look for opportunities to work as volunteers at this ISI. They also reported that it increased their motivation, interest, and improved attitude towards the topic. One of the teachers provided copies of final report of the expected outcomes from this visit. However, this was only possible in this one case since this teacher had the opportunity to visit the ISI earlier with her students and so had the time to integrate learning.

While the students reported that they enjoyed the trip immensely, most said they would have liked to be engaged in some hands-on task at the site. They wanted to be questioned by the ISI staff, instead of being subjected to a narrative which they received all throughout the day (Student Interviews, 02 & 04 December, 2013). Some also started to develop the idea of having career opportunities after one of the ISI staff mentioned that he was a postgraduate student and worked part time at this venue. They felt that the fact sheet provided by the ISI helped them learn about the physical layout of the enclosures, its inception, and the number of endangered species present. However, they said "we like to do more and listen less" which suggested they wanted to participate in activities at the ISI which had curriculum links and related to classroom practice (Student Interviews, 02 & 04 December, 2013).

After meeting with HoF on 30 June 2013, before the visit, the researcher had made a phone call to Mr. Linc stating that LEOS was considered by the school as an important way to learn science, and what the researcher was trying to achieve was to integrate learning at ISI and the students using Moodle. However, the response from Mr. Linc was that he saw ICT as a "distractor" to learning. Despite further attempts by the researcher, he did not clarify what he meant by this comment. The researcher sent an email to Mr. Linc to explain the project and inquired about his qualifications and position he held at the ISI. The reply email stated that he claimed he was "one of the most experienced outside the classroom teacher in New Zealand" and any more information could be obtained by visiting their website.

After the ISI visit, the researcher contacted the ISI staff, Mr. Linc while he was still on site to explain the purpose of this research project, and gain his support. Again he declined from speaking to the researcher. When approached, he kept moving away towards the car park and then started using his cell phone. By this time, the students and teachers had boarded the school bus and so the researcher decided to leave and make contact with Mr. Linc at a later stage.

As noted above, due to timing issues with the visit being held in the last week of teaching calendar, no post-visit activities were conducted by the teachers. The teachers reported that "they were just filling up time with some off-site activities," and that "it is too late in the year to be of any use" (Teacher Interviews, 02 December, 2013). One teacher's interviewed reported that "I will not even see them now" (Teacher Interviews, 02 December, 2013). Interviews with students revealed a similar feedback that they will "not have any more lessons with their teachers". This seemed consistent with the notion of the ISI visit been seen as a "day out", or a reward and not as part of the curriculum despite the official position taken by the school in their documentation.

5.4.4 Section Summary

In summary, the students expressed the view that taking learning outside the school helped them see endangered species, their habitats, and changes in population due to the eradication of pests and how the animals co-existed with other species. That is, they felt they developed an appreciation for this ecological reserve and its significance to the society and to the country, New Zealand. The students were largely impressed by the age of some of the trees standing in the forest. Some were reportedly 2000 years old, and this motivated a discussion within students. It was interesting to note that they tried to link the time of birth of the tree with other historical events in New Zealand. Even though these students had visited websites of this ecological reserve and explored the endangered species, they claimed that observing real species and having guided walk around the different habitats helped reinforce the information on the need for conservation of these endangered animals (Student Interview, 04 December, 2013). Section 5.5, which follows, provide the Chapter summary.

5.5 Chapter Summary

This chapter provided a description of the research findings for the first research question:

Research Question One

Are New Zealand teachers' current practices in LEOS effective in producing the desired learning outcomes for developing scientific understanding as evaluated against the New Zealand Curriculum achievement objectives?

It thus provided insight to the views held and the current practices pertaining to LEOS in Year 10 science classrooms at *Rural High School*.

The findings reported that while the ISIs was seen to have huge potential for informal learning, where student learning is self-paced and self-directed, the practices adopted at *Rural High School* lacked both in terms of pre-planning and post-visit activities with no direct link made to the curriculum. These findings were similar to those reported in the literature in Chapter 2. The findings thus suggested that students were engrossed in discussing extracurricular events such as their camping trip, which they had returned from and did not really have much idea of what they were expected to do at the ISI. Thus they did not view the LEOS as a learning opportunity. Similarly, the teachers, whilst having no say in the preparation of this trip, did realise that there were no activities organised post-visit, indicating that this was likely because it was the last day of the year. Teacher planning did not appear to draw upon students' prior experience and knowledge, or to allow any free-choice learning; for example allowing students to choose a particular pest they wished to explore in-depth. There was also disparity between what Mr. Macdonald, the Teacher-in-Charge had asked to be done at the ISI, and how Mr. Linc actually conducted the onsite activities. On a positive note, it seemed that students enjoyed visiting the ISI and felt that they learnt new things especially the opportunity to observe live species like *Tuatara*, but wanted to feel more involved and participate in hands-on activities.

In summary, the findings reported here suggest that the students were positive about LEOS, and as noted in the literature, there was a need for pre- and post-visit planning with more engaging activities at the ISI. It also seemed that collaborative and free choice learning was largely absent. It was suggested that the potential benefits of LEOS, may be realized by the use of a LMS, Moodle, to assist in integrating all three types of learning, which is the focus of the intervention discussed in Chapter 6.

CHAPTER SIX
RESEARCH FINDINGS: INTERGRATION OF FORMAL, NON-FORMAL AND INFORMAL LEARNING VIA DIGITAL TECHNOLOGIES

Overview of the Chapter

This chapter provides a description of the intervention employed in this inquiry, thus addressing Research Question 2. Interventions were conducted across three science curriculum strands namely, *Making Sense of the Physical World* (Physics), *Making Sense of the Living World* (Biology) and *Planet Earth and Beyond* (Astronomy). Section 6.1 begins with a summary of findings for the first research question, and describes the current practices involved in LEOS at *Rural High School*. Section 6.2 describes the intervention and curriculum framework involving three achievement standards: Physics (SC 1.4 AS 90943), Biology (BI 1.2 AS 90926) and Astronomy (SC 1.15 AS90954). Sections 6.3, 6.4 and 6.5 discuss the three phases of the intervention in detail: The preparation involved and learning outcomes at all three stages, *Before, During* and *After* LEOS for these three achievement standards. Section 6.6 presents the Chapter summary. Section 6.1, which follows, discuss the overall findings from Chapter 5. Figure 6.1 illustrates the different areas explored during this inquiry, which includes the current practices and the digitally integrated learning model.

6.1 Summary of Findings: Current Practice in LEOS at *Rural High School*

The overall aim of this inquiry was to gain a better understanding of how LEOS might improve the learning outcomes of science. The research question one sought to determine current practice, and as reported in Chapter 1:

Research Question One

Are New Zealand teachers' current practices in LEOS effective in producing the desired learning outcomes for developing scientific understanding as evaluated against the New Zealand Curriculum achievement objectives?

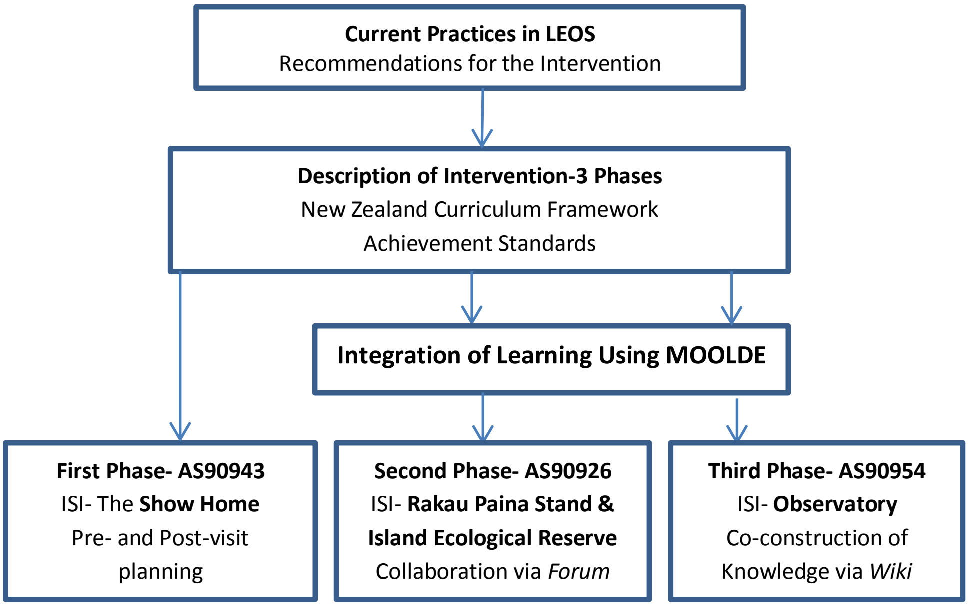

Figure 6.1: Describes the areas explored in this inquiry which includes the current practices and digitally integrated learning model

As noted in Chapter 5, *Rural High School* is a large co-educational, independent, day and boarding school for students in Years 7-13 (11-17 years old). It is a decile 10 school (i.e. high socio-economic) located in a rural area with students who are both locally based and from abroad. LEOS was ostensibly an important part of the school and featured in the Science Faculty calendar, although there was no formal school policy on LEOS. Another important observation made from the School Handbook was an emphasis on the use of digital technology to enhance students learning across the different curriculum areas, hence the BYOD programme. A separate 'prep time' also was part of the school day programme where students could visit the computer suites or the library, and use these digital devices to consolidate their learning.

The findings from this inquiry suggested that the topic of 'Pest Ecology' had been taught at this school for several years and students visited the same ISI at the end of their classroom study, mainly at the end of the year to avoid disruption to any other lessons. The same approach to data gathering was adopted each year where students laid traps around the school to identify pest presence on school site, and then visited the ISI to study the effects of pest eradication on a larger scale.

In the year of this inquiry, there were no data collected about pests at the school because there were no prints other than domestic or feral cats; as a consequence, the Teacher-in-Charge, Mr. Macdonald, decided to use previous year's data. Development of discursive meaning employed semantic content analysis as indicated in Section 4.6. From interviews with science teachers it seemed that completing any pre-visit tasks was not deemed compulsory. Teachers left the research findings and completion of work to the students. In the classroom, before the ISI visit, only a handful of students had processed their data, drew graphs or made inferences from the trends observed. Equally, only one of the ten teachers interviewed said that she marked and submitted work back to students. This teacher also stated that her students had prepared 10 focus questions to explore during the visit, but there was no evidence of this in student worksheets.

Pre-visit: During class time, students had visited the website of the ISI and read about its history, funding and its importance. Teachers reported that they had covered the following concepts: Food chains, food webs, ecological niche, biodiversity, biosecurity, nutrient cycles, energy flow, predator-prey relationship, and human influence on ecosystems (see Appendix O). While the student instruction sheet (*Pest Ecology-Investigating the Rat Population in [Rural High School] Community and Pest Impacts on Island Ecological Reserve*-see Appendix Q) read that this study was done once a week for half a term; the findings from the interviews indicated that it was only done for three hours, and only for a week. The teacher's went on to say they wanted the students to experience a live setting to appreciate the fragile nature of ecosystems, and they felt that the learning gained at the ISI would reinforce what was covered in the classroom. Some teachers also suggested that students could gain a lot from such site visit. "The visit should be done while the topic is currently taught". They saw their own roles as merely maintaining discipline, and "not anything to do per se" during the visit. They all expected the "experts" to share their knowledge with these students. The teachers felt that they had "covered the topic" thoroughly in class, even though the off-site data collection was to be done some months later. There were no assessment results to support this claim. It was also interesting to note that some students expected to do some work before going on a visit, performing some tasks at the site and completing the remainder of the work when they returned to school. One group reported that while they had collected data in school and had processed it, there were "a few gaps in their report, which they would complete after the visit". However, they went on to say that "due to time constraints, they were not able to complete their report because tomorrow was the last day of school".

During the visit: All students evidenced wonderment about seeing a 200 year old *Tuatara*, a native lizard, and the *Kakapo*, a rare, endangered bird, and climbing up the tower to appreciate the scenic view, all of which were low in priority according to the student instruction sheet (see Appendix Q). The other most popular activity with the students was seeing the variety of traps used in pest control, even though they had seen pictures of the same traps on the ISI website. None of the students reported knowing what was going to happen at the ISI before the trip, besides the fact that they were visiting it to "study wildlife". It was also interesting to note that when students were asked during focus group interviews (Student Interviews, 04 December, 2013) what they would like changed about the way this LEOS was conducted, they mentioned the following (typical quotes cited below) :

- All of the students indicated they wanted to be "informed of the activities" which would to be carried out during the visit;
- Almost all of the students indicated they did not like to be *told* about something, but wanted to be *taught*. When probed they suggested that if the "guide could ask them questions" based on the work they did in the classroom and link it to the context they were studying in, it would have made "learning more meaningful";
- All of the students indicated they wanted a "lesson and not a tour" of the site;
- They all wanted the "lesson to be interactive" where they were asked questions on the work they had done in class;
- All of the students indicated they wanted the "learning intentions and learning outcomes identified before the trip" so they could monitor their level of learning. While they were given a worksheet on the site, neither the teachers nor the ISI staff made any reference to this during the trip, and so the students reported that they did not look at it at all;
- Almost all of the students indicated that they found the information they gathered at the ISI to be only "general information" that lacked any curriculum links; and

- They thought that the objective of the visit was "more like forest conservation with limited if any links" to what they had learnt in the classroom.

Post Visit: Feedback from focus group interviews with students after the visit suggested two learning outcomes were achieved; namely, low level factual recall of information, and the increased motivation to learn about the fragility of New Zealand ecosystems. The learning outcomes as perceived from the marking criteria of this assessment (see Appendix Q) used by *Rural High School* were that the student should be able to:

- Record and process field data, analyse the population of rats over time, and describe a factor that might be causing changes in the rat populations;
- Describe the physical set up of *Island Ecological Reserve*;
- Describe three native plants and three native animals;
- Describe the different methods of controlling pests such as baiting, trapping, spraying plants and hunting;
- Explain the effects to native mammals or plants of leaving pests in the area without monitoring;
- Graph and analyse the rat population throughout the year and the potential causes for these patterns;
- Discuss how the '*Maunga'* (Māori word for mountain) became an ecological island; and
- Using the collected data, make recommendations to the school on the rat population, potential consequences of action or inaction.

Due to the delay in the ISI visit, both staff and students reported, as noted in Chapter 5, no activities were conducted after the visit. The students, however, said that they were looking forward to completing their reports. They also emphasised that while they enjoyed the visit to the ISI, they wanted the learning to be more interactive. They were keen to share their findings with their peers to identify the level of understanding they had about pest control. These students stated that one way to find out if they have learnt something is when they can "share that understanding with their friends" (Student Interviews, 05 December, 2013). Section 6.1.1, which follows, discuss recommendations for the intervention.

6.1.1. Recommendations for the Intervention

Five recommendations were made based on the findings from Chapter 5. Analysis of these findings suggests that LEOS can help enhance the learning of science, if the following are done:

- The objectives of the trip are strongly linked with classroom teaching and students are informed of these and what they are expected to do at the ISI. Teachers should prepare classroom lessons which allow adequate preparations for an ISI visit;
- The tasks designed to facilitate learning at the ISI should draw upon students' prior experience and knowledge, is interactive, and allow some freedom of choice in learning;
- Trips to ISIs are planned so they run concurrent to the topic being taught, and not left to the end of the year. This will ensure that there is enough time for post-visit activities to be completed;
- The ISI staff are informed of the objectives of the visit in order to prepare for targeted activities which allow group learning. This ensures the students interact with the ISI staff (both guides and the presenters) instead of just listening to a pre-planned presentation; and
- Collaborative knowledge building and taking responsibility for learning are some of the objectives of informal learning conducted during and after LEOS. The use of the learning management system, Moodle, should be used to assist in these collaborations.

In summary, "we can do better". Thereafter, the researcher worked with these teachers to implement these recommendations with a particular emphasis on utilizing digital technologies, namely Moodle, as a learning management system, which could be used by students to communicate with each other both before and after ISI visits with an overall intention of enhancing collaboration between students and between students and teachers in order to improve learning outcomes. The intervention study in Section 6.2 includes a strong emphasis on pre- and post-visit planning of LEOS and the use of two features of Moodle, namely *forum* and *wiki*, to help facilitate students "cognitive engagement and co-construction of knowledge".

6.2 Description of the Intervention

The research question two for this inquiry as reported in Chapter 1 is:

Research Question Two

Is an intervention based on learning support provided by digital means effective in producing desired learning outcomes when evaluated against the New Zealand Curriculum achievement objectives? Next, Section 6.2.1 discusses the New Zealand Curriculum Framework.

6.2.1 The New Zealand Curriculum Framework

This section provides some background on *The New Zealand Curriculum Framework*, with emphasis on the achievement standards explored in this inquiry. This provides the scope of the intervention, as it was concerned with three different strands of the framework. The following section presents an outline of the intervention, which describes the activities and personnel involved at the three stages of each phase of the intervention in this inquiry; *pre-visit, during the visit* and *post-visit* for all three different Level 1 achievement standards studied.

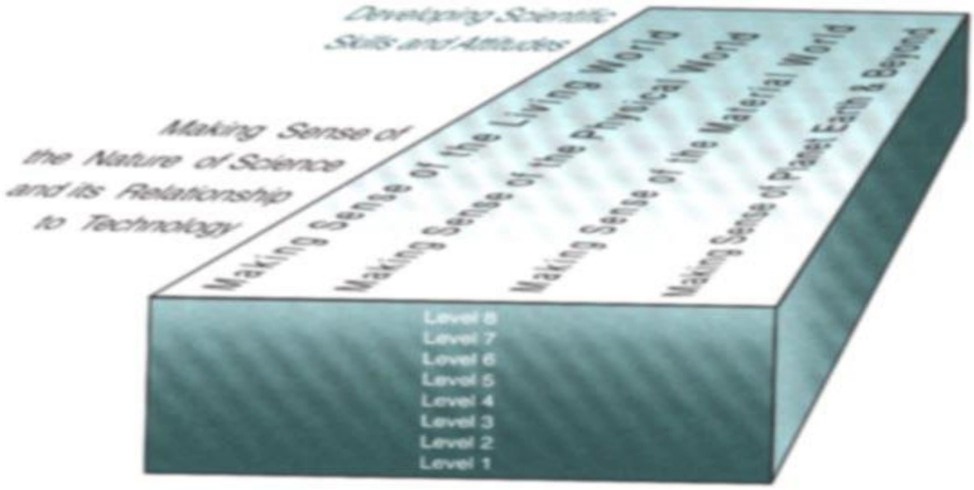

Figure 6.2: The New Zealand Curriculum Framework: Showing four learning strand and two integrating strands (MoE, 1993, p. 16).

A review of the New Zealand Curriculum was undertaken in the years 2000-2002. According to the Ministry, the Curriculum is a "clear statement of what is deemed important in education in New Zealand. It has a vision to create students' as lifelong students, who are confident and creative, connected and actively involved" (MoE, p. 4, 2007). The science curriculum is presented in a way where learning spans eight levels, and is described in sets of achievement objectives; these in turn are organized within learning strands (Ministry of Education, 1993). There are two groups of learning strands; The *Contextual Strands*, and the *Integrating Strands*. The former, is made up of four strands called *Making Sense of the Living World, Making Sense of the Physical World, Making Sense of the Material World,* and *Making Sense of Planet Earth and Beyond.* The integrating strands are called *Making Sense of Nature of Science and its Relationship to Technology,* and *Developing Science Skills and Attitudes*. Each strand is divided into eight levels, which "describe the progression of the science curriculum from junior to senior secondary levels" (MoE, 1993, p. 15).

A number of achievement objectives are described in each strand and at each level. At each level, the achievement objective describes the expected learning in science. For Levels 1-5 (7-14 years old), the achievement objectives are linked, on average, to a two year period of learning; for Levels 6, 7 and 8 (NCEA Levels 1, 2 & 3 for students aged 15-17 years), the objectives are linked to a one year period of learning.

The curriculum statement encourages teachers to link achievement objectives from different strands to provide integrated learning experiences. This allows schools to prepare their own school science scheme. It is intended that the school science scheme sets the specific learning outcomes, which are derived from the achievement objectives as this provides the learning criteria, and which is used to structure the learning experiences for the students. Although the learning objectives can be prescriptive, the learning contexts, possible learning experiences and assessment types should allow flexibility in how the aims and objectives can be fulfilled. So what will be common across all schools in New Zealand, is that their science schemes will target the attainment of the same achievement objectives, but they will (and indeed should) use different contexts and learning experiences, as well as different formative assessment regimes, to attain the learning described by these achievement objectives.

The curriculum also identifies "*seven* teaching approaches that consistently have a positive impact on student learning called *Effective Pedagogy*" [original emphasis] (Ministry of Education, 2007, p. 34). What follows is a description of the three most relevant approaches for this inquiry:

- *Facilitating Shared Learning*: This is where the students learn as they engage in shared activities and conversations with other people such as family members, their group members, in this case ISI staff and people in the wider community. "The teachers are required to create the classroom as a learning community where there is a learning partnership through learning conversations between the students and between the teacher and the students" (Ministry of Education, 2007, p. 34). This allows the students to engage in a reflective discourse with others and they build the language, science jargon, that they need to in order to take their learning further;
- *Providing Sufficient Opportunities to Learn*: Here "students learn most effectively when they have time and opportunity to engage with, practice and transfer new learning" (Ministry of Education, 2007, p. 34). This means that they need to encounter new learning and in a variety of different tasks and contexts. This provides the scope for LEOS which forms the fundamental basis of this inquiry; and
- *E-learning and Pedagogy*: ICT has considerable potential to support the teaching approaches outlined above. "E-learning helps provide a new learning environment which helps students to make *connections* with each other, *facilitate shared learning* by allowing students to create communities of learners beyond the classroom, helps create a *supportive learning environment* where students may share resources and finally enhance opportunities to learn by offering students virtual experiences which allows them to take their learning further" [original emphasis] (Ministry of Education, 2007, p. 36) and this is also discussed in Chapter 3).

The findings from the first stage of the inquiry were then used to modify the practice of LEOS at *Rural High School*. This occurred in three phases involving the same cohort of students, each phase dealing with a different learning area. In the first phase the learning area was Physics, and here the emphasis was on better planning of pre- and post-visit activities. In the second phase, the learning area was Biology, and here the focus was building on the first phase, but incorporating the use of the *forum* to help students engage in informal learning and sharing ideas using a LMS. The intention here was for them to get used to using the digital space in Moodle for learning. In the third phase, the learning area was space science, Astronomy, and building on the first two phases, the students now engaged in the co-construction of knowledge using the *wiki* feature of Moodle. Next, Section 6.2.2, describes the achievement standards of the New Zealand Curriculum.

6.2.2 The New Zealand Curriculum Achievement Standards

The aims of science education in New Zealand are expressed as a series of achievement standards and these "provide the themes that link the achievement objectives of one level to the next" (MoE, 1997, p. 17). The three standards investigated in this inquiry are discussed below.

The first standard was AS90943: *The Design Game: Keeping Your Home Warm*, a standard which belonged to *Making Sense of The Physical World* strand (MoE, 2007). According to the curriculum: "This strand provides explanation for a wide range of physical phenomena, including light, sound, heat, electricity, wave, forces, motion and energy. By studying this strand, the students will gain an understanding of interactions between parts of the physical world, understand a wide range of contemporary issues and challenges and potential technological problems" (MoE, 2007, p. 45).

The second standard explored was AS90926: *A Biological Issue*, *Protecting Biodiversity*, which belonged to *Making Sense of The Living World* strand (MoE, 2007). This strand focused on living things, and how they interact with each other and the environment. Here, "students are expected to develop an understanding of the diversity of life, life processes, and of the impact of humans on other forms of life. As a result, it is intended that they will be able to make decisions about significant biological issues, such as the sustainability of New Zealand's unique flora and fauna and its distinctive fragile ecosystems" (MoE, 2007, p. 45).

The third standard studied was AS90954: *Astronomical Cycle and its Effects on Planet Earth*, a standard which belonged to *Making Sense of The Planet Earth and Beyond* strand (MoE, 2007). This strand is about linking the astronomical cycles such as spin of the Earth, orbit of the Earth around the Sun, and the orbit of the Moon around the Earth, and their effects on planet Earth. Students are expected to "develop an understanding of how the movement of the three celestial bodies impact on the weather, phases of the Moon, tidal movement and in creating solar and lunar eclipses. As a result, it is intended that students will be able to appreciate interconnecting systems and processes on the Earth, the other parts of the Solar System, and the Universe beyond" (MoE, 2007, p. 45).

The overall aim of the inquiry was to gain an understanding of the students' experiences of LEOS, and to see if the integration of digital technologies helped enhance learning outcomes in these three standards. The students', teachers and ISI staff ideas about LEOS were probed using semi-structured focus group interview protocol (see Appendix L) before and after the ISI site visit. Other sources of data included classroom observations, field notes during LEOS, student work books and assessment reports, teacher notes, assessment record, and teaching resources, posting on *forum* and *wiki*. Eliciting students' views on LEOS and the integration of learning using digital technologies comprised of six steps (Table 6.1).

Table 6.1: Six steps: Integration of LEOS with digital technologies

1. Pre-visit: Semi-structured focus group interview: *Can you tell me the purpose of this visit?*
2. Observation of classroom practice before the visit: *What type of preparation is done in classrooms for the visit?*
3. Observation of the type of interactions between teacher, student and ISI staff at the ISI: *Was there any opportunity for free choice learning?*
4. Post-visit: Semi-structured focus group interviews: *What have you learned from the trip?*
5. Observation of classroom practice after the visit: *Did the classroom lesson draw upon the information gathered at the ISI?*
6. Use of digital technologies, Moodle, to integrate learning: *Were forum and wiki sites used to allow for collaborative learning to occur?*

6.3 First Phase of the Intervention: Physics (AS 90943): Visit to *The Show Home*

6.3.1 Setting the Scene: Teachers' and Students' Views

The Year 11 science programmes are at Level 6 of the New Zealand curriculum, and this first phase of the study is based on the strand called *Making Sense of the Physical World*. The achievement standard AS90943 titled, *Investigate Implications of Heat for Everyday Life* required students to explain the processes of heat transfer namely, convection, conduction and radiation, describe thermal insulation and design a house floor plan which is heat or insulation efficient. The two teachers involved in this phase of the inquiry were Ms. Harris (HoF), and Mr. Smith, who were highly qualified and experienced teachers. Mr. Smith had a PhD in Civil Engineering. Informal interviews with Ms. Harris suggested that she was keen to use digital technologies to support her classroom practice, while Mr. Smith, was rather more skeptical. He said that "at the end of the day we are judged by parents on the number of students passing this course". He went on to comment that in his view, "introducing students to programmes on Moodle can distract them, and this will affect their results for this standard."

The teachers shared the resources for teaching this unit (see Appendix H). The Level 1 Science, AS90943: *Implications of Heat for Everyday Life* lesson overview shows that the topic was taught for three weeks, while the students were given eight days to complete the internal assessment, which included visit to the *Show Home*.

The researcher approached both teachers three months before the planned visit to inform them about the intervention she wished to carry out with the teachers and students. She conducted two workshops for all science teachers in the Faculty of Science to educate them on the different features of Moodle and to discuss how she wanted to use two of these features namely *forum* and *wiki* for student-student and teacher-student collaboration. Most teachers during these two workshops expressed enthusiasm about learning the different features of Moodle, and thought that it had value and "could be used in their classroom". One teacher asked, "How do we make sure that no obscene material like a picture of a penis is posted by students during these collaborations?" (Teacher Interviews, 10 March, 2013). The researcher informed the teachers that they should be moderating the postings on a regular basis, that is, “daily to ensure only on-task discussions are posted or retained” (Teacher Interviews, 10 March, 2013).

The teachers also were told that the student groups should use face-to-face classroom sessions primarily to meet, discuss and make postings which are to be used by the teachers for diagnostic assessment of students’ prior knowledge and abilities in the subject area. Additionally, the teachers were asked to make comments on these sites, in order to encourage creativity and in-depth discussions amoung students. As mentioned in Section 4.2, contributions and editing of the *wiki* and *forum* were done once the meetings and discussions were completed, that is, outside classroom time, at home or during Study Zone/Homework periods when students were allocated time to use the computer suites. Each group was made up of eight participants, each characterised by diversity in gender, academic ability and experience with NML.

Five groups of eight students in Year 11 (15 years old) were told about the purpose of these interviews; these were the same students who were interviewed for the first research question of this inquiry, when they were in Year 10. They were asked 10 questions (see Appendix L), and allowed adequate time to respond to each question.

6.3.2 Pre-Visit Activities

Observations of classroom activities showed clear planning and preparation for LEOS by teachers, in stark contrast with the findings for the first research question in this inquiry. Moreover, the pre-visit activities that were completed in the classroom conveyed a strong correlation between the during-visit and the post-visit plans. The LEOS composed of an integrated teaching model to help enhance student’s learning outcomes in science. At this phase of the inquiry, the first three weeks were used to teach three concepts; convection, conduction and radiation, using lesson notes, tutorial discussions and conducting set experiments as per the Unit Plan (see Appendix H). These aimed to provide exposure to a range of scientific theories, models and discussions about the concepts being studied. This was fairly passive, with students mainly copying information in their workbook, but they conducted research into areas which needed to be explored, especially to explain observations made during science experiments. Students used textbooks, and resources posted on the Moodle, such as video clips and other relevant literature. Development of discursive meaning employed semantic content analysis as indicated in Section 4.6.

Before the visit, the students were expected to know the difference between the terms "heat", "temperature", "heat capacity" and "thermal resistance" (R-value). In the past, according to Ms. Harris, she used notes and sometimes practical sessions to discuss these concepts. The students were mainly required to know the definitions. Ms. Harris had visited the *Show Home* to collect resources to develop a student worksheet (see Appendix R). The students were to collect information using these worksheets, which they would use to "complete their internal assessment report". She had checked with the manager of the *Show Home*, to ensure the designer, ISI staff, would be present to talk to the students: "I have informed the ISI staff what the students are seeking from this visit" (HoF Interview, 15 March, 2013). The ISI staff member was informed of the objectives of the visit in order to prepare for targeted activities which allowed group discussions. This sought to ensure the students interacted with the ISI staff instead of just listening to a pre-planned presentation. The work sheets had spaces for designing a new home which was energy efficient. The following question was posed at the beginning of the Unit: "You are going to imagine that you are an architect (someone who designs houses) and design *your own* home. You will produce a floor-plan of *your home* and then consider the heat implications of the home *you* have designed." Some house plans and designs were provided by the ISI to be used for classroom teaching before the visit (see Appendix S for more details).

The researcher discussed the purpose and perceived value of the field trips during the focus group interviews before the visit, excerpts of which follow (all names are pseudonyms). One can perceive from students' feedback that they saw it as a reward only. However, when asked about the purpose, they were better able to link it to what they were learning in the classroom.

Interviewer: Why do you want to go on field trips?
Kyla: One and a half hours of out of school time. It's fun. We don't go on trips. It is good because we can be with our friends. We are told to behave or we may not go.
Interviewer: What is the main purpose of this visit?
Beatrice: They show you materials which insulate heat such as double glazed glass compared to normal glass. It gives us a better understanding of what we are learning in class. We will take notes at the site which will help us pass our internal [assessment].
Bryar: Air movement of particles inside the house, double glazing.

When questioned further, these students were able to articulate responses which showed the link between learning in the classroom, and what they expected at the ISI.

Interviewer: What are some of the things you enjoy about LEOS?
Brodie: Different type of learning, prefer more field trips. LEOS is better. I get a better idea on what is happening, bring the knowledge back to class and share with my mates.
Granger: It is actually happening. You can see it and take notes. The *Show Home* is good, it give us a better understanding. I will be able to see the process of conduction in different materials.

The students started comparing types of insulation in old and new homes and made suggestions for future visits.

Interviewer: Do you think there are things which should be changed about this trip? Why?
Drew: Something which should be thought about for future is also to make a visit to an old home so you could compare the differences in heating efficiency of the two.
Jedd: May be we should look at an older house also to see what has changed in terms of insulation.
Logan: I have been to open home before and it is pretty good. More trips are good.
While there was great enthusiasm expressed by both staff and students for LEOS, the same could not be said about the use of Moodle as a learning platform.

The students described Moodle as a repository of resources, which was only accessed to get notes on the different subjects. The students reported that in the past they had mainly used Moodle to get information on Mathematics. It was the first time this year that they were accessing it to get information on Science. While the term ‘Moodle’ was known by all students interviewed, they did not seem to be aware of the many features of this learning platform even though the school had been “using it for six years”, according to the HoF. The students stated that Moodle was used to obtain “slide shows and practice examination papers,” suggesting it was being used as a repository of resources, rather than a collaborative learning platform (Student Interviews, 26 March, 2014).

The researcher then tried to find out how the school used Moodle and what the students thought of it during focus group interviews before the visit, excerpts of which follow.

Interviewer: Was any work done via Moodle before you visited the *Show Home*?
Lily: I use Moodle every day. When I go to the library, I jump on to Moodle. It is best for people who are away for catch up. I get all my papers from there.
Astrid: Not many people enjoy Moodle. No work was done on Moodle.
Xanthe: We got documents off Moodle. We haven’t been on Moodle otherwise.
Kyla: We got documents on heat insulation and some practice questions.

It was evident from student responses that they were not familiar with the affordances of Moodle.

On Thursday, 27 March 2014, at 9.00 am, the group of 40 students with 2 teachers travelled on a school bus to visit the ISI, the *Show Home* in a nearby local town. They were greeted by the Manager at the entrance and all students were asked to move inside the house for a general briefing.

6.3.3 Activities Carried Out During the Visit

At the ISI, the Manager provided a brief history about the business and encouraged students to ask questions they wished. The students were then divided into two groups led by the Manager and the Designer. The groups explored the outside and the inside designs of the house alternatively to avoid overcrowding. The students then discussed questions which they had constructed in the classroom, and the worksheet provided by their teachers. They also had the opportunity to make inquiries with the ISI staff. To include some *free choice* in learning at this ISI, students had the capacity of exploring topics of their own choice, which were not assessed. Students could explore different types of building materials and they also had a choice of designing a home of their own choosing (Field Notes, ISI visit, 27 March 2014). This was much enjoyed by students and one stated that, “I know the kind of home I will build when I settle down.” Another student displayed a likeness for building and design and reported that he was thinking of taking it up as a future career: “I do graphic and design at school, and this is something I will enjoy doing.” (Field Notes, ISI visit, 27 March 2014). Students became actively engaged with the tasks they had to do at the ISI as shown in the photographs below.

Figure 6.3: Images of students interacting with each other and with the ISI staff at the *Show Home* when learning about building materials and design

After spending two hours at the ISI, the students and teachers returned to school while the researcher stayed back to interview the ISI staff. The researcher planned to meet these students the following day during their science lessons to find out more about their experiences and also observe post-visit activities before writing their assessment.

6.3.4 Post- Visit Activities

After the students had left with their two teachers on the school bus, the researcher approached the ISI staff, Mr. Jeff to discuss the visit. Overall, he was positive about the visit, and he said he felt that the pre-planning by Ms. Harris helped facilitate the visit better.

Interviewer: How did you think the visit went?
Mr. Jeff: Good, for the kids. A lot easier for kids to understand because the information is first hand. They are standing in the house, they can ask questions on various bits and pieces, makes a little bit more real rather than being in a classroom.
Interviewer: What do you think the students learned?
Mr. Jeff: There is a lot to designing a house. There is a lot more to it - such as the sun, views, the type of materials used all become part of the design especially when you look at insulation. Particularly the different materials used to design the floor, double glazed glass and heating systems. If you want glass, you can't have it all on the south side. The students learnt why designing are important for building homes in New Zealand, especially when it comes to building heating efficient homes.
Interviewer: How do you know that they have learnt that?
Mr. Jeff: The students asked me questions on the design, insulation, double glazing and heating systems. I was also pleased that some students want to come back and visit us. They are most welcome and we want our young generation to learn more about house design and making it heating efficient. During the tour of the *Show Home*, the teacher also asked questions which I am sure will help students gather information for their project.

As noted above, the ISI staff were informed of the expectations of this visit, and was able to engage the students by providing interactive learning sessions during the visit.

The researcher met with the students and teachers for informal interviews. Focus group interviews with students revealed that they appreciated going on visits outside the school which helped them see "real things" and "improve understanding of the concepts" learnt in class. They enjoyed being with their friends outside school, and this year, they thought that the activities were more targeted and purposeful.

Interviewer: Did you know what the purpose of this visit was?
Astrid: To find out about the types of insulation used in building a house.
Xanthe: To see how to better insulate a house.
Interviewer: Why do you want to know this?
Astrid: Oh well, we were taught that heat travels through conduction and convection and so we just wanna see how it really happens.
Xanthe: I want to know what all is needed to design a house, like types of glass, orientation for sun. I need this to do my internal.

They were very pleased to be able to visit the *Show Home*, even though most of the students interviewed reported that they had been to one before, but this time it was "with mates" and to "do some studies". Some students reported that they enjoyed being able to talk to the ISI staff who were professional designers and builders. The teachers from the Faculty of Science were keen on the concept of integrating their classroom teaching with LEOS. They had done this previously (in Year 10, 2013), and the HoF suggested that she made sure that the Faculty had taken up recommendations made in the researchers report on 15 January, 2014 (see Appendix M). While the HoF expressed dismay on the lack of LEOS for all areas of NCEA level science curriculum, she suggested that the Faculty was looking at having at least some standards integrate classroom teaching with LEOS. She went on to say that she was "concerned with the standard on science and space, AS90954, which has the least number of NCEA passes in the earlier years" (HoF Interview, 12 March, 2014). She went on to suggest that it would be important that students visit an ISI when they delivered that achievement standard because they lacked teaching resources.

Interviews with teachers involved in this study revealed that they felt they experienced tremendous benefits from integrating classroom practice with LEOS. Mr. Smith, for example, was highly enthusiastic about the potential of LEOS for enhancing learning, and was questioned as to why he felt this approach had value.

Interviewer: Why do you think LEOS is important?
Mr. Smith: Students can literally see the house design, talk to the designer and the architect, proper person. The students can see the materials used and the end product, which is the modern house.

Interviewer: Do you see any other benefits of LEOS?

Mr. Smith: The students can ask the designer relevant questions. I also believe, the students can talk to each other because they have been paired up for the first part of this internal and share the notes which they take at the ISI.

While LEOS was seen as having potential to enhance learning outcomes in science, the use of Moodle to facilitate learning even after conducting workshops on its affordances seem to have little usage in most science classrooms.

Interviewer: Do you think Moodle can help in collaborating between these students and with teachers like you?

Mr. Smith: While I believe that LEOS does enhance the learning of science, I feel that online chat-type *forum*s will be a distractor. From my experience, Moodle *forum* and or *wiki* can mainly be used for topics which include views and opinions. It does not really work for topics like this one.

Ms. Harris was very enthusiastic. She saw LEOS as a way to motivate students, and link classroom science to the "real world". She strongly believed that it helped contextualize learning and helped improve students understanding of science. She also seemed to believe that students would benefit if Moodle was integrated with classroom practice.

Interviewer: Why do you think LEOS is important?

Ms. Harris: Kids get a lot more out when they visit places. They can actually see the physical layout, explore their own interest, in this case was the design of their own house. I am sure different groups preferred different design layouts. They get a better understanding on the ideas involving insulation and the products used. Going to a place like this is a new exposure; it's more contextual and off course will help in their internal assessment.

Interviewer: Do you see any other benefits of LEOS?

Ms. Harris: Well they get a better understanding on the relevance of 'R values'. They can see why the house was built in that way, mainly orientation, view and heating. They also have the opportunity to learn from the designer and share their ideas and findings with members of their team. They can ask the designer questions straight away if they are not clear. Integration of both LEOS and Moodle could certainly enhance learning of science.

Integrating learning in classrooms with LEOS using digital technologies are discussed next in Section 6.3.5.

6.3.5 Integrated Learning: LEOS with Digital Technologies

Whilst there was strong evidence for pre- and post-visit planning, helpful interactions with the ISI staff, and teacher workshops, the integration of Moodle with LEOS did not occur in this phase of the inquiry. Interviews with students revealed that the Moodle site was only visited to download resources on the topic under study. So whilst Moodle was used to support LEOS, it did not enhance learning. It seems Moodle here was used in much the same way as it had been used traditionally at *Rural High School*; viz., as a repository for science content. Additionally, as noted above most students said they had never heard of *forum* and *wiki* before. While the term "collaboration" seemed foreign to most, they appeared to have some understanding that it was to do with "talking and sharing work and resources" with each other.

Interviewer: Can Moodle be used for collaborative learning?
Jedd: Collaboration, what do you mean? Talk to each other, which will be nice. It is hard for me because I have never done it before.
Drew: I have no idea. Is it to talk and check other people's ideas?
Craig: Also, can we watch the video which Ms. Harris had on Moodle and discuss with our mates? That will be awesome!
Lani: I found it difficult to understand the table of R values. Can we talk on what did you say *forum*, and that other thing to learn what R value means when we are at home?
Interviewer: Yes you can.
Lani: That will be cool, cos I don't get it at all.
Brodie: So can we use *wiki*, whatever, to share what we learnt at the *Show Home*?
Interviewer: Of course you can.
Brodie: Have you done this before.
Interviewer: At the university, this is what we mostly use to share our work and

research findings with other students and our supervisors because most of them are remotely based.
Brodie: Really! That sounds like fun. Can we try this?
Interviewer: Ask your teachers and I am sure they will support you.

The conversation then shifted on to the use of Moodle to stimulate discussion and cognitive interactions. Here it seems they saw Moodle as inferior to other more familiar communication tools.

Interviewer: Can Moodle be used for collaboration between students, how?
Sheldon: Collaboration, what do you mean? I think emails are better for discussion. Moodle is really confusing to talk with. Have you seen a group chat? Emails are easier because we have been using it for longer. Moodle are good for getting documents. I don't think we have used it for discussions. I don't like using it.
Jethro: Moodle probably is better between student and teacher communication rather than between students.
Billy: More for people who are away to catch up.

Next, the interview focused on using Moodle to enhance learning. It soon became apparent that the students did not see Moodle as a learning management system and they had little knowledge of how it could be used to enhance learning, at least in part because of lack of familiarity with its functionality.

Interviewer: Do you think Moodle *forum* and *wiki* can be used to help you learn the topic better, if yes how?
Beatrice: What is a *forum*, is it just the Moodle? What's the other one?

Kyla: We usually have discussions in class, after class we email our teacher. It will be useful to use Moodle for after classroom hours for discussions. So where does the information in these Moodle *forum* come from? Does it come from Wikipedia?
Drew: If you go to Moodle, download all resources, and then you don't have to go to the classroom. What is a *forum*, I don't know? Can you talk to people on Moodle? Talk to anyone online [laughs].

Jedd: Yeah, you can get other people's opinion on work and stuff, ask them questions, to see what they are thinking and to see if you are right.

Craig: Moodle can be used for discussions, yeah! I find way better to learn with Moodle. I like to learn at my own pace. I use Moodle every day. I play games at the same time while I read my notes. The whole topic is on Moodle, resources and work sheets for the whole year.

Some of the students were enthusiastic about the use of Moodle for discussions, although it seems this functionality was not known to them until it was raised in the interviews. A week after the ISI visit, the researcher visited Ms. Harris to find out if she had used some of the activities on Moodle to integrate learning.

Interviewer: Did you try to help students discuss their findings from the *Show Home* using *wiki*?

Ms. Harris: I wanted to use *wiki* but there were not enough computers for all. Also, the students may not be brave enough to share their thoughts with each other. However, I do intend to do this in a couple of my lessons.

Ms. Harris: The person in charge for ICT was away for the week, so I could not get it going, sorry. I know that if I had managed to do it, it would have helped improve students' understanding of their visit.

The other teacher, Mr. Smith, likewise reported not using Moodle. Consistent with his earlier interview comments, he seemed anxious about the impact of what he saw as non-core activities on student achievement.

Mr. Smith: I did not use *forum* or *wiki* because the students were not familiar with it and I did not want to spend my teaching time on making them learn how to use these features. I better spend my time teaching them the scientific concepts. Also, I don't want to experiment this new teaching style because it can affect my pass rate for this standard. Here at this school, we are judged by the number of students getting through each standard.

Section 6.3.3, which follows, discusses student assessment results for AS90943: *The Design Game: Keeping Your Home Warm*.

6.3.6 Student Assessment Results

The assessment task employed for this achievement standard had been used by the Faculty for a number of years, and was one which was enjoyed by students. In the past, the students visited the HoF house, which was on the school property, a house which belonged to the Board of Trustees. The HoF was provided with this accommodation because she helped look after the boarding students after hours, supervising their studies and meal times. This was the first time, when students visited the *Show Home* and gained information from ISI staff.

The internal assessment results were encouraging and the reports revealed that students displayed in-depth understanding of science concepts such as heating efficiency and 'R values' (Thermal Resistance) of building materials. The table below shows students' performance in AS90943 between 2013 and 2014.

Table 6.2: Summary of assessment results for AS90943: *The Design Game, Keeping Your Home Warm* between 2013 and 2014

Year	Not Achieved	Achieved	Achieved at Merit	Achieved at Excellence
2014	19	35	25	21
2013	44	41	9	6

It was also evident that students made use of the findings they had gathered from the ISI and used them to write their reports for internal assessment, which was completed as a post-visit activity. However, there were also students who did not succeed in this assessment for a variety of reasons which according to the HoF was due to absenteeism, incompletion of tasks, and lack of details in their report (see Appendix T).

6.3.7 Section Summary

This section summarizes the findings from the first phase of the study:

- Students enjoyed learning in groups at a site other than school;
- Better pre- and post-visit planning helped ISI staff to prepare more targeted and interactive activities which was enjoyed by both students and teachers;
- Interactions with ISI staff (designers and builders) provided opportunities to discuss questions which otherwise would have been impossible;
- LEOS provided opportunities for students to see building materials and the end product, a modern home;
- Students were able to develop a better understanding of the 'R values', something they struggled to understand in the classroom;
- Inclusion of free choice learning maintained focus, motivation and enthusiasm during the visit which allowed more interactions between students and between students and ISI staff;
- Possibilities of taking up house design as career choice was also expressed, one of the outcomes of informal learning during LEOS;
- Better planning by teachers enabled students to realise that LEOS was a learning opportunity instead of a reward trip;
- There was a significant improvement in students' performance for AS90954 as compared to 2013; and
- Students were still unaware of the affordances of Moodle.

While *Rural High School* had effectively implemented most of these recommendations (see Chapter 5), the same could not be said about the use of Moodle for collaborative learning as reported in the findings above.

The overall theme of integrating LEOS with digital technologies, in this case using two features of Moodle, namely *forum* and *wiki*, was to increase the level of cognitive engagement which would subsequently improve students' level of attainment in their internal assessment. Whilst this was the expected outcome of the intervention, interviews with students, teachers involved and student assessment results displayed a variety of responses.

The next phase placed emphasis on using Moodle features, in particular *forum*, which allowed collaborative learning digitally between students and between teachers and students. Section 6.4, which follows, discusses the second phase of the intervention: *Report on a Biological Issue Protecting Biodiversity*.

6.4 Second Phase of the Intervention: Biology (AS 90926): Visit to *Rakau Paina* Stand and the *Island Ecological Reserve*

6.4.1 Setting the Scene: Collaborative Learning Using Moodle

While, most of the recommendations made in Chapter 5 were included in planning as seen in the first phase of the intervention, the planning lacked the use of LMS to be used as a platform for collaborative learning and helping students' co-construct knowledge. Development of discursive meaning employed semantic content analysis as indicated in Section 4.6. Interviews with students suggested very limited knowledge of the different features of Moodle. The only function noted of this learning platform was a repository of resources. However, students in their interviews said "that one way to find out if I have learnt something is when I can share that understanding with my friends" (Student Interviews, 27 March, 2014). This statement tends to suggested that there was a possibility of creating a community of learners where students shared their thoughts and ideas using a learning platform. In the second phase of the study, *forum* was used to create a collaborative learning environment. Next, Section 6.4.2 discusses the inclusion of *forum* as part of the pre-visit preparations.

6.4.2 Integration of Forum During Pre-Visit Preparations

As stated earlier, the Year 11 Science programmes are at Level 6 of the New Zealand curriculum, and this second phase of the intervention is based on the strand called *Making Sense of the Living World*. The achievement standard AS90926, *Issues of Protecting Biodiversity in New Zealand* required students to collect and process information and write a report which discusses why protecting New Zealand's biodiversity is an issue, the important biological ideas about biodiversity and the differing viewpoints that people have about protecting biodiversity. Two teachers involved in this phase of the inquiry were Mrs. Lomas (HoD Biology), and Mr. Gibbs.

The researcher made contact with both teachers two months before the intervention. These teachers had more than 10 years of teaching service at this school. They were advised of the procedures to be adopted during this study, which included data collection pre-visit, during-visit and post-visit, and the inclusion of digital technologies to help integrate learning and improve the learning outcomes for this standard. The researcher strived to make sure that the two teachers saw themselves as an important part of the learning community and were actively involved in moderating the postings on *forum* and *wiki* made by students. This engagement was intended to help ensure students were guided in their knowledge construction processes when interacting via Moodle. The researcher conducted an in-class student induction to both *forum* and *wiki* features of Moodle, which appeared to be appreciated by teachers and students alike. Interviews with the students after the induction session suggested that they saw this method of learning "very different", but were keen to use it because they "could discuss the topic with each other while they were at home." The inclusion of Information and Technology (ICT) Department in this study assisted the researcher in gaining access to both teachers' home pages and students' sites on Moodle which was mutually beneficial. The remote access to student work on Moodle also enabled constant monitoring and feedback to both staff and student.

Unlike the pest control study conducted in Year 10, where the teachers with the help of students collected possible footprints of the pests around the school for the first part of the study, in this second phase of intervention, Mrs. Lomas invited specialists from the Regional Council to address the students on biosecurity concerns for New Zealand flora and fauna. *Rural High School* is an Enviroschool as noted in Chapter 5, and is affiliated with Enviro-Organizations who help provide specialist assistance not only with information on this topic, but have also worked with teachers and students over the years at *Rural High School* to regenerate the *Rakau Paina* Stand (New Zealand Pine Forest) of the school which was once badly damaged by pests and pathogens. This provided an excellent opportunity for non-formal learning, which was also conducted outside school.

In discussion with Ms. Audrey an ISI staff member (Leader of the Regional Council Team), one can sense the value she placed on pre-planning, and in particular how she used pre-visit school interactions to plan the activities on the day of the visit.

Interviewer: What contact did you have with the teacher before the visit?
Ms. Audrey: Had a phone conversation and she also emailed what she wanted us to do about a month ago. She wanted me to explore the different ways to engage the kids. She emphasised the need to have a set of different examples and also that the students had questions to ask us. Together we brainstormed all different ideas and amalgamated into what we are doing today for the kids.
Interviewer: So what activity have you planned for them?
Ms. Audrey: A thinking activity. The activities about "what if scenario" and trying to incorporate what they have learnt in the classroom as well as from other stations. For example, if we continue to have drought situation and did not have rain for a while, what would you do to help the *Rakau Paina* Stand grow?

There were four stations prepared for students to visit and collect information. Each station was attended by an ISI staff that was knowledgeable in a specific area, such as animal pest control, plant pest control, biological control, and biosecurity. Each station provided some information to help solve the "what if scenario" activity. The set up by the team included group activities as well as opportunities for the development of problem solving skills. Figure 6.4 shows student groups at the different stations.

In the classroom, the teachers shared resources for teaching this Unit (see Appendix I). AS90926: *Issues on Protecting Biodiversity* Unit Plan, showed that the topic was taught for four weeks, while the students were given five days to complete the internal assessment, which included visits to both, the *Rakau Paina* Stand on the outskirts of the school and the *Island Ecological Reserve*.

Figure 6.4: Students participating in group activities presented by the Regional Council Team, which are closely monitored by their subject teachers

According to the teachers, LEOS was a very important part of this standard, because it enabled "students to have sensory experience as well as an opportunity to develop a personal connection with the biological issue facing that ecosystem" (Teacher Interviews, 03 September, 2014). The teachers emphasised that not all schools had this opportunity and they were fortunate that this type of integrated learning approach would help their students in making the experience a “real issue”. The teachers strongly believed that integrating these experiences will help improve students’ performance in this standard; "With the inclusion of specialists from the Regional Council Team and visiting and learning from ISI staff, we are confident that student’s reports will show depth and breadth" (Teacher Interviews, 03 September, 2014).

A new person included in this trip was the School Career Advisor. While she was asked to help with student supervision, she was also asked by the Deputy School Principal to build professional relationships with ISI staff; look for career opportunities for students and, seeks possibilities for these students to take up volunteer roles at the site during school holidays. Interviews with her suggested that she was very keen, and it gave her an opportunity to develop a better student profile.

She was impressed with the information shared by the specialists, especially on career journey, which they pursued during the years before they joined the Regional Council. She suggested that such information and being with students off-site helped know students better "and when they visit my office to discuss career opportunities, I will use this information as an ice-breaker for our discussions on making career choices and looking for volunteer jobs for holidays (Field Notes, 04 September, 2014)."

Observations of the second phase evidenced classes conducted differently from the first phase of the intervention. Most of the lessons were conducted in the library, which was adjacent to the computer room using a blended learning environment.

Figure 6.5: Image of a blended learning environment where the students are using both, digital and face-to-face discussions to help improve their understanding on biological issues

The teachers had posted a selection of website addresses in a document titled "Web Quest" (see Appendix I) which students used to gain introduction to the topic. They searched websites for information on biosecurity and answered questions provided by the teacher. This created group discussions not only in the library, but students started to use the computer room, in particular, the *forum* site, to share their findings with each other. The postings on forum also included pictures.

As stated in Chapter 3, Lemke (1996) identified LMS as the interactive learning platform where learning is predominantly a networked (connected) activity. This became the focus of this phase of the inquiry. There were several *forum* postings made by students for pre-visit activities. The *forum* site was used by groups for sharing their findings and updating their postings. Members of each different group had the opportunity to critique each other's findings. The excerpt given below is a discussion on *forum* between students which was facilitated by their teachers (all names are pseudonyms).

Definition of Biosecurity

by Jane- Monday, 1 September 2014, 9:55 AM

Biosecurity is the protection of a country's, environment from unwanted exotic pests and diseases. It includes trying to prevent new pests and diseases from arriving, and eradicating or controlling those already present. In New Zealand action is taken to prevent unwanted organisms from damaging the economy, natural biodiversity, or the health of the New Zealand public. The Department of Conservation states "Biosecurity is about keeping New Zealand free of unwanted organisms and for controlling, managing or eradicating them should they arrive in the country, to prevent or reduce any damage these may cause should they occur, and to protect and preserve the land, water, industry and people of New Zealand". Threats include the arrival of new invasive species into New Zealand, which are a threat to our environment. These invasive species can include plants, animals, insects, birds, fish and diseases.

The students clearly found the definition helpful in setting the scene, meaning they felt they understood the key terms, as Jane above notes:

Re: Definition of Biosecurity

by Andrew - Monday, 1 September 2014, 10:00 AM

Thank you for your insightful knowledge. It has made me a lot smarter.

The teacher then tried to stimulate discussion, pointing out that this helps in learning :

Re: Definition of Biosecurity

by Drew - Thursday, 4 September 2014, 8:54 PM

A thorough response from Jane.

Re: Definition of Biosecurity

by Teacher - Thursday, 4 September 2014, 9.00 PM

But I would like for you Drew to also add to what was said instead of simply acknowledging the responses. Discussion helps the team to learn together. How is biodiversity related to biosecurity?

The student responded well to this prompt from the teacher and then began to engage in group discussions:

Re: Definition of Biosecurity
by Drew - Thursday, 4 September 2014, 9:00 AM
Biosecurity enables the protecting of our biodiversity and there are several agencies responsible for this.
Re: Definition of Biosecurity
by Andrew - Thursday, 4 September 2014, 10:00 AM
ok. So what are the different organizations involved in protecting biodiversity?

Other students soon joined in commenting and showing that they had used the Internet to find government organizations that had an interest in, or responsibility for biosecurity.

Re: Responsible Organizations
by Drew - Thursday, 4 September 2014, 12:57 PM
I have found that the ministry of agriculture and forestry is overall in charge of biosecurity. others include
The Ministry for the Environment (offsite link to www.mfe.govt.nz)
Ministry of Tourism (offsite link to www.tourism.govt.nz)
Tourism New Zealand (offsite link to www.tourisminfo.govt.nz)
Ministry for Economic Development (offsite link to www.med.govt.nz)
Ministry of Foreign Affairs and Trade (offsite link to www.mfat.govt.nz)
Ministry of Health (offsite link to www.moh.govt.nz)
Land Information New Zealand (offsite link to www.linz.govt.nz)
Ministry of Fisheries (offsite link to www.fish.govt.nz)
the Department of Conservation (offsite link to www.doc.govt.nz)
Environmental Risk Management Authority (offsite link to www.ermanz.govt.nz)
Customs (offsite link to www.customs.govt.nz)

Crown Research Institutes (offsite link to www.morst.govt.nz)

National Institute of Water and Atmospheric Research (offsite link to www.niwa.co.nz)

New Zealand Food Safety Authority (offsite link to www.nzfsa.govt.nz)

Figure 6.6: Year 11 students at *Rural High School* collaborating via *forum* to develop a common understanding of the term biosecurity

The teachers thus took an active role in providing both leading questions as well as moderating *forum* discussions. The teachers used face-to-face classroom sessions primarily to meet and discuss biological concepts, key terms and definitions, and how they linked to the concept of biodiversity. They also used Power-Point presentations to discuss issues such as threatened species, biosecurity and extinction. These lessons were followed by posting information, which was used by the teachers for diagnostic assessment of students' prior knowledge and abilities in the subject area. Teachers moderated these sites, to encourage creativity as well as in-depth discussions amoung students. Classroom observation showed that the teachers made effort to explain the purpose of the LEOS and asked the groups to construct three questions, which they wished to ask the ISI staff. The diversity in the types of questions allowed for some degree of free choice in learning. Some of the questions asked were:

- How does what you do impact on biodiversity in New Zealand;
- Do you think there is a species which is undervalued;
- What pest do you think is most damaging to New Zealand, and why do you think that is the case;
- Is biodiversity in this country improving; and
- Do you think the government values the type of job you do? Why?

As mentioned in Section 4.2, contributions and editing of the *wiki* and *forum* were done once the meetings and discussions were completed, that is, outside classroom time, at home or during *Study Zone/Homework* periods when students were allocated time to use the computer suites. Next, Section 6.4.3 describes the activities carried out before visiting both the ISIs.

6.4.3 *Findings from the Pre-Visit Activities*

In this second phase of the study, each group was made up of eight participants, characterised by diversity in gender, academic ability and experience in NML. Five groups of eight students in Year 11 (15 years old) were told about the purpose of these interviews; most of them were the same students who were interviewed for the first phase of the study. They were asked 10 questions (see Appendix L) and allowed adequate time to respond to each question.

The researcher discussed the purpose and perceived value of the field trips during the focus group interviews before the visit, excerpts of which follow (all names are pseudonyms). The researcher here tried to find out if students had adequate knowledge of the intended visit. It could be perceived from student responses that students had developed adequate prior knowledge from learning as a community via *forum*. Some even made suggestions for changes if this LEOS became part of school calendar.

Interviewer: What is the main purpose of this visit?
Beatrice: To learn about biosecurity from experts.
Bryar: To learn about biodiversity also.
Interviewer: So how are the two words linked, biodiversity and biosecurity
Beatrice: Biosecurity helps maintain biodiversity.

The students' perception of LEOS appeared to be curriculum related rather than only seen as a reward, which was the case in the first phase of study. They were keen about outdoor learning which gave them an opportunity to use their prior knowledge.

Interviewer: What are some of the things you enjoy about LEOS?
Brodie: It is different because you can actually see endangered animals like *kiwis* and pests such as possums and weasel.
Granger: You can actually see and learn how species interact with each other.
Interviewer: Do you think there are things which should be changed? Why?
Drew: Yes, it will be good to visit the airport customs to see how biosecurity is done and how they control pests from coming into New Zealand

Jed: May be we should also look at marine ports to see how boats are checked and anything stolen comes into New Zealand.

Interviewer: What do you mean by 'stolen'?

Logan: I mean like the exotic reptiles, which we see on television.

The researcher here tried to find out if students had used any of the features of Moodle to prepare for this trip. It was also intended to find out if students envisaged using Moodle as a collaborative tool.

Interviewer: Can you tell me what activities you have done prior to the visit?

Martin: We have learnt how to use Moodle *forum* and *wiki* and we have been grouped up to discuss the topic with each other.

Laura: We had been shown how to use *forum* and *wiki*. We did some work on *wiki* and discussed why fungi in Moana Island were both good and bad and should we conserve it. It was fun. While I thought we should kill it because it causes diseases, my friend suggested to keep it because it is endemic to our country. I like debates.

Interviewer: Can Moodle be used to collaborate between students?

Joseph: You can talk to each other, participate in multiple *forum* discussions and post articles for other students to read.

Beth: If you miss class and are at home, you can get some information. You can also share information which others agree or disagree and make changes and provide information why they felt that way.

The researcher here tried to find out if students perceived a difference in the way they saw the use of Moodle. It was encouraging to note the development of awareness on the affordances of Moodle.

Interviewer: Do you think *forum* and *wiki* sites can help you learn the topic better, if yes, how?

Joseph: Yes because you can share your ideas, interact with peers, learn information from each other and you can do this anytime during the day.

Granger: Yes because I can get information from my friends instead of finding the stuff myself. I can also take screen shots of the page and upload it to show where I got the information from. I can equally verify things I don't know and the teacher will also be checking the work and so I know I will get the right stuff.

Jed: The old Moodle I knew was only used by teachers to upload documents. This is the first time we are using *wiki* and *forum*. The new Moodle I know now, students can post articles. This is cool!

Logan: The Moodle is an information bank; *forum* is the collection of same information, which I can use to write my report. I don't have to go and look for the stuff. It is all found in one area. I can look at other peoples stuff.

Drew: It is awesome and I can use *forum* to do both class work and research. Moodle is the solution. I can use it anytime like doing a study talk.

The interviews with the students suggested that they were pleased about using features of Moodle such as *forum* and *wiki*. It was equally interesting to note the change of reason from the first phase of the study, why they wished to participate in LEOS. The students appear to show great adaptation to learn using both *wiki* and *forum* features even though the *forum* sites were seen to be used predominantly.

On Thursday, 04 September 2014, at 8.00 am, a group of 51 students with 4 teachers assembled in the *Rural High School,* Faculty of Science building. They were greeted by four members from the Regional Council Team (RCT) who were plant and animal pest officers as well as experts in the area of biosecurity in the region. Next, Section 6.4.4 describes the activities carried out during the visits to both the ISI, namely *Rakau Paina* Stand and the *Island Ecological Reserve*.

6.4.4 Activities Carried out During the Visit

Members of the Regional Council Team had set up four stations in the *Rakau Paina* Stand which was adjacent to the school. The activities were designed to enable students to think about how to solve problems, "What if scenarios". Mrs Lomas, the HoD, had informed the leader of the team, Ms. Audrey, to prepare activities which would "engage all learners". The stations were set in a way where the topics were linked and by the time students arrived at the last station, they had to have enough knowledge to be able to solve a biosecurity problem. The stations contained information on biosecurity related to diseases affecting plants, biodiversity which included the impact of possum and biodiversity with reference to control of weeds.

An example discussed was "what would you do if a disease was found to have affected the pine trees in the North Island?" (Field Notes, ISI visit, 04 September 2014). Students were asked to work in groups and present their findings to the station leader. More discussions followed between ISI staff and students after students presented their work (Field Notes, ISI visit, 04 September 2014). All four teachers helped facilitate discussions between students and between students and ISI staff to ensure that they were learning what was required of them at each station. "I now understand when dad and I go duck shooting; dad always tells me to clean all our gears. We could have brought some weed seeds with us. The *Purple nutsedge* is highly invasive and it competes with agricultural crops and can completely smother other native plants". Another student related an incident which was also on weed infestation. "Well, my dad goes eeling with his mate and he hates this landowner because he has put a fence across his farm and it makes it harder for dad to reach the stream. It makes sense to me now why the farmer did that. Dad and his mate could accidently bring *Alligator weed* which is a pest weed and it can affect the farm badly. It is toxic to livestock and it rapidly takes over pastures and crops" (Field Notes, ISI visit, 04 September 2014).

Interviews with Ms. Audrey, the leader of the Regional Council Team suggested that her team was impressed with the students and the types of questions they asked. One such example was linking the hypothetical case of disease spreading in *Rakau Paina* Stand with an actual case of *Psa virus* affecting Kiwi fruit vines. Ms. Audrey also commented that during the day, when students started the journey at her stand, “they seemed to have very little practical knowledge on weed control and how it helped improve biodiversity of species”. However, as the students visited three other stations and finally returned to her stand for the final stage of the ‘what if scenario case’, she was pleased to see the growth in their knowledge (Field Notes, ISI visit, 04 September 2014). She wanted to make sure that students build their knowledge and understanding and link these to the *Island Ecological Reserve* which was a large scale area where pests had been eradicated and resulted in an increase in species biodiversity. During her interview, she emphasised that she wanted students to become environmental stewards. Ms. Audrey and members of her team were equally happy to keep in touch with the students via email if they wished to pursue any question with them. She reaffirmed that they are an "environmental group and like helping students to learn about the environment and protect the biodiversity of species for future generation"(ISI Staff Interviews, 15 September, 2014). She nonetheless agreed that the way the lessons were delivered at the stations would have been different, if they were given more time: "Most of the lessons were basically transmitting knowledge. I would have preferred more hands-on activities (Field Notes, 04 September, 2014)."

In order to ensure continuity in learning, Mr. Linc, from *Island Ecological Reserve*, the ISI visited by these students in the previous year, was requested to join the students as they moved around the different stations to learn about biological issues from the RCT. Interviews with him suggested that the teachers had asked him to link what students learnt from the RCT with pest control and eradication which was his area of discussion. Again, this was a preparation carried out by the HoD and other teachers in consultation with the researcher to help integrate learning experiences from both outdoor learning sites. After completing the outdoor experience in the *Rakau Paina* Stand, the students were handed their lunch packs as they boarded the bus and headed towards the *Island Ecological Reserve*, to the visitor information centre before taking a tour of the reserve.

Figure 6.7: Students engaged in both non-formal and informal learning to enhance their understanding on biological issues concerning New Zealand's fragile ecosystems

After a brief introduction on the background of the place, the students were divided into three groups, each with ISI staff and teachers. The researcher accompanied one of the three groups. The tour started at the wet lands which was a habitat of an endangered native bird, the *Takahe.* The guided walk was interactive as the ISI staff provided information and the teacher helped relate it to what the students needed to know from the site. At one stage, the group stopped under a tall native tree, *Kauri*, which was said to be 100 years old. The tree was covered with insects and had other soft-stemmed plants and ferns growing on it. There were birds in the canopy with ants in burrows near the base of the stem.

Figure 6.8: Students learning in groups about a *Kauri* Tree ecosystem, influence of human on deforestation and its impact on species biodiversity

Mr Linc: This one plant will give you an answer to biodiversity. The question is what would happen if we sell the whole forest?

Mrs Lomas: So an issue on this would be, should we encourage logging of these trees if we own them? Should we harvest them all, or should we go for selective logging?

Drew: Selective logging.

Mrs. Lomas: Why?

Jed: So we don't disturb the habitat of these other species.

Mr Linc: When we do selective logging, we cannot take out the native plants, so in that way, the biodiversity of the organisms depended on these native plants are protected. However, we should still look after them.

The smaller group numbers allowed more interaction between the ISI staff and the students. During the tour, the students came across a plant covered with snails which became a topic for discussion. The questions asked by the ISI staff were linked to what students had learned in their classrooms and this allowed for more engagement.

Mr Linc: Here is a case of plants and animals co-existing in their natural habitat. What would happen if we spray these snails?
Brodie: Kills the snail.
Mr Linc: Yes of course, but will other species get affected by the death of snails?
Granger: The birds will have less food or may start eating some other organisms.
Mr Linc: That is a case of how human intervention can affect species biodiversity.

After spending an interactive three hours at the *Island Ecological Reserve*, the students started to show signs of tiredness and become quiet as compared to the early part of the day (Field Notes, ISI visit, 04 September 2014). The teachers then boarded all students onto the school bus and headed back to school. Next Section 6.4.5 describes the post-visit activities carried out by teachers, ISI staff and students.

6.4.5 Post-Visit Activities

After the students had left with their teachers on the school bus, the researcher approached the ISI staff, Mr. Linc to discuss the visit. He suggested that he preferred having a telephone interview the following day instead.

The researcher tried to find out how Mr. Linc had used his findings from the *Rakau Paina* Stand which he had attended in the morning and used it to link it to the work carried out by his team at the *Island Ecological Reserve*. The excerpt given below is a discussion between Mr Linc and the researcher.

Interviewer: How do you think the visits went?
Mr. Linc: I was underwhelmed by the Regional Council Team. They were boring and kept me disengaged and so they had made my job harder. The kids were good but we expect them to be, especially from that school.
Interviewer: What do you think the students learned?
Mr. Linc: I guess that there are a lot more involved in looking after biodiversity than what they were aware of, especially in terms of the different organisations.

Interviewer: How do you think they have learnt that?

Mr. Linc: Oh because the students had the opportunity to interact with different professionals, and this would help them to learn better and see the different roles they play in protecting the species.

Interviewer: How do you know they have learnt that?

Mr. Linc: The students asked questions whenever information was shared. This shows engagement and that they understand better. Also, these students had visited us last year, so that helped them relate to things better.

After concluding the informal interview with Mr. Linc, the researcher then called Ms. Audrey from the Regional Council Team.

Interviewer: How do you think the trip went?

Ms. Audrey: Extremely well. When I started with the first group, I had to probe their thinking, but after they visited other stations and came back to me, they had gained enough prior knowledge and could process and utilise in the "what if scenarios" which I had for them. They could articulate what they had learnt from other stations and really think of solutions.

Interviewer: What do you think the students learned?

Ms. Audrey: There are pests throughout the country. I wanted them to learn about the importance of biosecurity. Also, I wanted them to become more responsible. I asked them as to who should notice if pines look sick and who should alert the right authorities. Is it important to have the pine forest in order to maintain biodiversity? Awareness on biosecurity: what that actually means in terms of potential threat, e.g. *Kauri dieback*. They could articulate some animal pest information. Recognising that we have animal pests and we should be doing something about it and also recognise that we are not doing enough.

The interactions between the researcher and Ms. Audrey suggested that her team was pleased with student engagement at the different stations. There was evidence of improvement in students understanding on biosecurity and its importance. However, she acknowledged the fact that her team could have made the sessions more engaging if they had been given more time but the team was pleased with the types of feedback students shared during the discussions.

Interviewer: How do you think they learned that?

Ms. Audrey: We shared this knowledge mainly by transmission though, where each specialist talked about their area of expertise followed by group activities. If there was more time, I would have done it differently. I would have had more hand-on type of activity rather than just listening to us.

Interviewer: How do you know they learned that?

Ms. Audrey: From the discussions which went on in groups. I asked probing questions to find out what they had learned and they were very good at articulating their responses. If they retain that knowledge and take any action, is up to them really. I cannot say much. I hope that the visit to the *Island Ecological Reserve* did give them the feeling of a place which is pest free and this may bring about an intrinsic change. We hope.

Discussions with the two different ISI leaders suggested that they thought students had gained immensely from these LEOS. Although Mr. Linc thought that the presentation by the Regional Council Team was "boring". Also, having more specialists working with the students allowed more interaction and students could explore topics of their own interest. The sessions allowed for group activities where students also developed problem solving skills.

The following day, the researcher met with the teachers for informal interviews at school. The researcher tried to find out how pre-planning and liaison with ISI staff affected the events of the day. It could be perceived from these discussions that the teachers preferred the presentation by the Regional Council Team because it was more targeted to the topics studied by students in the classroom. The extra reading materials they provided were deemed useful.

The excerpt given below is a discussion between the teachers and the researcher.

Interviewer: How do you think these visits went?
Mrs Lomas: The presenters in the morning session were excellent and more engaging than the afternoon one.
Mr Gibbs: I agree. The Regional Council Team was informative. The examples used were more specific and students related well to those information. Also, the brochures supplied contained information students would use for their assessment.
Interviewer: How do you know that students enjoyed their presentation?
Mrs. Lomas: The Regional Council Team did exactly what I had asked them to cover during their presentation. The topics discussed were very useful and presented using language which students can understand. Students asked questions on *Kauri dieback* which is a disease affecting the *Kauri* plants. That shows that they were interested.

Once again, the ISI staff from *Island Ecological Reserve*, Mr. Linc, did not meet the requirements of the LEOS even though several correspondences were made between the teacher and him. The teachers expressed concern for lack of flexibility in both planning the events of the day and cost of the trip, but they expressed appreciation for the efforts made by the two guides at the ISI.

Interviewer: Why do you think the afternoon session was not that effective?
Mrs. Lomas: The ISI Staff did not do exactly what I had asked him. It was the same presentation from last year which the students said that they found boring. However, I found out from other students that the other two guides were very interesting and discussed a lot of issues affecting biodiversity, which students really enjoyed.
Interviewer: Are you trying to say that the ISI Staff at *Island Ecological Reserve* have a set programme and did not adopt changes to the way the schools wanted the programme to be run.
Mrs. Lomas (*very reluctantly*): Yes. I don't think I will go back to them anymore. Also, even though there were a total of 76 pupils booked for the trip, 20 were away due to sports events and we had informed them about this change of figures some time ago, they still insisted that we pay the whole amount, not a good idea.
Interviewer: What do you think your students learned?
Mrs. Lomas: Strategies to protect biodiversity. Especially the discussion by the

Regional Council Team on *Kauri dieback* was good. These are fungus like organisms which are affecting our *Kauri* trees.
Interviewer: How do you know the students learned that?
Mrs. Lomas: More than half the student population did their projects on topics related to the topics discussed by the members from the Regional Council Team and only a few did it on pest management and biodiversity which was what was discussed at the Island Ecological Reserve. There were quite a number of pupils who researched *1080* and its impact on biodiversity. Again a topic shared by the Regional Council Team.

The researcher then tried to explore the provision for limited free choice in learning when engaging in LEOS. It was interesting to note that there were opportunities and students made effective use of this.

Interviewer: Was there any free choice learning included when planning for LEOS?
Mrs. Lomas: The LEOS was supposed to provide them with sensory experience as well as a holistic introduction to the topic, but definitely the topics discussed would have enabled them to choose one which they wished to pursue at depth when doing their internal assessment. However, these topics were needed to be approved by me first to make sure that the students knew what they had to write about. They also had three questions which they had constructed as a group to explore with the specialists.

From these discussions, it appeared that the presentation by the Regional Council Team was preferred over the guided tour of the *Island Ecological Reserve*. It was also noted that liaison with ISI staff especially Ms. Audrey's team, during pre-planning ensured that the activities were more targeted. Inclusion of specialists in the different areas of study on biodiversity allowed students freedom to choose an area which was interesting to them. While this was true, students needed approval from their teachers before they completed their report, hence, there was limited freedom of choice for learning, an important attribute of informal learning.

On the same day, the researcher met again with the students and held focus group interviews to discuss about the visit. Here, the researcher was interested to find out how students perceived the LEOS. The excerpt given below is a discussion between students and the researcher.

Interviewer: Did you enjoy the visit?

Kyla: The trip was very good because I started to understand more about native species.

Interviewer: What do you think you learned?

Drew: I learned about native plants and how they benefit us.

Interviewer: How did you learn that?

Beatrice: Well, we were given a guided tour of *Island Ecological Reserve* where we were told about the importance of certain plants and the way if affects the species abundance in the forest. He also talked about endangered animals.

The researcher then tried to find out what experiences students had during the guided walk and if they achieved any learning outcomes.

Jedd: He was good because he told us a lot of information about the bush and birds and what they had to do to help keep this area safe etc. Jeff was a very good speaker and he sounded like he knew what he was doing. Our group got a wide range of information from him and we had stops every 10-15 minutes to talk about that area we were in.

Interviewer: How do you know you learned that?

Bianca: I can discuss the topic better because I now know more than I did before.

It could be perceived from student feedback that they enjoyed the guided tour which was interactive, included humor and also provided them with necessary information (Field Notes, 04 September, 2014). It was also evident that students enjoyed having enthusiastic guides, who shared their personal experiences with them and answered all their inquiries (Field Notes, 04 September, 2014). The researcher then tried to find out if students used *forum* to collaborate. It was apparent that the teachers had asked questions related to the two outdoor learning experiences and student actively engaged in responding to these inquiries. It could be perceived that the experiences were rewarding and it certainly enhanced their understanding on biosecurity and biodiversity and the reasons for the inclusion of different organisation. The excerpt given below is a *forum* discussion between students and the questions posted by their teachers (all names are pseudonyms).

Re: Did visiting the *Island Ecological Reserve* and *Rakau Paina* Stand change anything for you?

by Bryar - Friday, 5 September 2014, 3:01 PM

Yes, I got more in depth information about biodiversity and opened up my mind to plenty of new problems I could use for my internal

Re: Did visiting the *Island Ecological Reserve* and *Rakau Paina* Stand ecosystems change anything for you?

by Kyla - Friday, 5 September 2014, 3:03 PM

yes, this made the topic more meaningful to me as I have a better understanding and a wider knowledge of biodiversity

by Beatrice - Friday, 5 September 2014, 3:05 PM

yes, it helped me to see the diversity of species at *Island Ecological Reserve* and have the presenters explain it in depth and answer the questions that I had about it. The presentations at the *Rakau Paina* Stand helped me to understand more about biosecurity and what we can do to help biodiversity in NZ

by Lily - Friday, 5 September 2014, 6:14 PM

Yes it was quite interesting to learn about all these possible problems. As well as the actual problems out there with biodiversity.

by Drew - Friday, 5 September 2014, 7:09 PM

I found going to the *Island Ecological Reserve* and *Rakau Paina* Stand helped me understand the difference between both ecosystems. The presentations in the *Rakau Paina* Stand helped me learn about the *Kauri dieback* and *Island Ecological Reserve* showed how the vegetation is much improved with the pest proof fence.

Figure 6.9: Students collaborating via forum after visiting both ISIs, namely *Rakau Paina* Stand and *Island Ecological Reserve*

Here, the researcher tried to find out what students perceived to be useful attributes of *forum*. The students seemed to have differing points of views about the effectiveness of collaborating using *forum*.

The excerpt given below is a discussion between students and the researcher.

Interviewer: Can Moodle be used for collaboration between students, how?
Jethro: Yes, you can post a statement and someone can reply, which is very handy.
Jedd: It's cool, because you don't have to read all the stuff. Other students read and make comments which I find useful and it's faster than reading it myself.
Granger: Personally, I prefer to learn from the teacher in class. I think that *forum* and *wiki* should only be used outside the classroom. I easily get distracted.
Bianca: It helps you but teaching in the class is better for me. You can seek information in the class and the teacher will help. I prefer to work with the teacher.

Overall, it seemed that the teachers and students enjoyed the trips. The students collected new information to help them complete their report. While some students were less pleased with Mr. Linc, because he lacked humour and was less encouraging, the other two ISI staff were greatly appreciated because they were passionate about their work and also included humour in their presentations. Both teachers and students expressed appreciation of the work presented by the Regional Council Team. However, students held different perceptions on the use of *forum* for collaborative learning. While a large cohort were quite impressed with the way it could be used, a minority showed total dependence on learning via teacher only was better.

When the students returned to school after the visits, they were given a week to collate all data and research materials from the websites and use them to complete their report. During this time, the teachers used both classroom sessions as well as the *forum* sites on Moodle to help extend the students' knowledge on biological issues affecting the biodiversity of native species. They were given two hours to complete the written report under test conditions. These reports were marked using the answer schedule put together by the Department and a sample of the paper was moderated to check consistency in marking (see Appendix T). The assessments results are discussed next, in Section 6.4.6.

6.4.6 Student Assessment Results

The assessment task used this year was the same as the one used by the Department last year. The one change adopted this year was offering the students a variety of different species to select from to discuss the biological issues relating to biodiversity of their chosen species. Informal interviews with both teachers suggested that last year, students did not engage in LEOS and neither did the school invite any specialists to discuss the topic in class. Teaching was predominantly carried out by the teacher and all students were given one pest to investigate and write about.

The teaching and learning this year allowed for experiential learning where students visited two different sites and had discussions with specialists who were involved in looking after the biosecurity and the biodiversity of species in the region. Interviews with students suggested that the experience was rewarding, even though some students wanted to visit a different site other than the one they had visited last year. It was also encouraging to note from focus group interviews that student's developed a different perception of the different features of Moodle. They seemed to be able to articulate more informed responses and the postings on the *forum* demonstrated collaborative learning which was enjoyed by most of the pupils. It was also interesting to note that while *forum* was widely used, only a few postings were made on *wiki*. Informal interviews with both staff and students suggested that they could achieve "an e-learning community via *forum* and so did not have to use *wiki*". One teacher said that "we focused on *forum* only because there was not enough time to teach them how to use *wiki* to the same extent also. After all, students responded well on *forum*". The table below shows students' performance in AS90926 between 2013 and 2014.

Table 6.3: Summary of assessment results for AS90926: *Report on a Biological Issue* between 2013 and 2014

Year	Not Achieved	Achieved	Achieved at Merit	Achieved at Excellence
2014	7	39	32	22
2013	0	50	29	21

While the internal assessment results were encouraging, there were five students who did not perform well. Interviews with teachers suggested that these students were away for a long period attending sports tournament overseas. Other reasons were "poor literacy and numeracy skills, resistance to ask for help, low self-esteem leading to a tendency to try and hide academic struggles and poor subject choice. Three of these students did not visit the two sites either and made no contribution on *forum*". However, the researcher was informed that the students "may elect to do the task/unit again on a different topic next year".

6.4.7 Section Summary

This section summarizes the findings from second phase of the study:

- It was encouraging to note the effective use of nearly all recommendations from (Chapter 5);
- There was effective teacher planning for both pre- and post-visit activities;
- Being an Enviroschool perhaps enriched interactions between the teachers and the Regional Council Team to prepare more targeted activities;
- The inclusion of specialist personnel helped provide a deeper insight to the topic. Also the involvement of the School Career Advisor assisted in building professional links with the ISI;
- Adoption of a blended learning environment provided exposure to a different way of collaborating for learning;
- Only the *forum* feature was used in these collaborations with very little use of *wiki*;
- Student discussions at the ISI displayed links between curriculum and ISI tasks which also included their personal experiences;
- Lack of provision for hands-on activities at *Rakau Paina* Stand due to time constraints;
- Teachers assumed a slightly different role as compared to the first phase of the study where they helped facilitate discussions between students and ISI staff; and
- A slight improvement in students' performance in their internal assessments was also noted.

While the teachers had made an effort to integrate LEOS with digital technologies, it was noted that only one feature of Moodle was utilized by students as noted above.

The third phase of the study places emphasis on using Moodle features particularly *wiki* which allows the development of NML through co-construction of knowledge amoung student. Section 6.5, which follows, discusses the third phase of the intervention: *Report on Astronomical Cycles and Effect on Earth.*

6.5 Third Phase of the Intervention: Astronomy (AS 90954): Visit to the Observatory

6.5.1 Setting the Scene: Co-Construction of Knowledge Using Moodle

The first phase was predominantly about improving the planning of LEOS, with a strong emphasis on pre- and post-planning and liaising with ISI staff for more targeted activities which would allow learner engagement. The second phase focused on the use of *forum* for collaborative learning, between students and between students and teachers. The third and last phase discusses the use of *wiki* in order to develop NML skills to help enhance the learning outcomes of science during LEOS. The intention here was the use of *wiki* would help students engage in the co-construction of knowledge, drawing upon multiple sources of information, which they obtained from different websites, other text resources, as well as the ISI staff and their teachers. The intention then, is that this would subsequently help enhance their academic performance in this achievement standard. Development of discursive meaning employed semantic content analysis as indicated in Section 4.6.

This Section thus discusses the last phase of implementation for this inquiry. The study included the same cohort of students from the previous two phases, but different teachers from the Faculty of Science at *Rural High School*. The ISI visited was to an observatory and similar procedures as in the previous two phases were undertaken for the preparation of LEOS.

Pre-visit Activities: As stated above, the Year 11 Science programmes are at Level 6 of the New Zealand curriculum, and the topic studied at this phase of the study is based on the strand *Planet Earth and Beyond*. The achievement standard that formed the focus for the study is AS90954, *Astronomical Cycles and Effect on Earth*. The assessment activity required students to comprehensively research and gather information on at least 2 astronomical cycles of the Moon and their effects on Earth. The possible Astronomical cycles to be chosen from were; Spin of the Moon, Orbit of the Moon Around the Earth, and the Interaction of the Moon and Earth Orbiting the Sun. The possible effects on Planet Earth could be selected from; formation of tides, Neap and Spring tides, phases of the Moon and Lunar eclipse. There were two teachers involved in this phase of the study; Ms. Clare, and Mr. Hoyle. While Ms. Clare had about 15 years of teaching experience, Mr. Hoyle was new to the profession. However, he was known as the “rocket man” in the School, a nickname attributed by the students because of his interest in automated rockets, which he frequently used to create exciting demonstrations during annual Science Fairs.

The researcher approached both teachers a month before the planned visit to inform them about the intervention she wished to carry out with the teachers and students. She conducted three informal sessions with the two teachers to educate them on the different features of Moodle, and discussed how she wanted to use, in particular *wiki*, for student-student and teacher-student collaboration. Based on the feedback from the second phase of this inquiry, the researcher decided to hold *wiki* induction lessons with students again. These lessons sought to inform the students about how to use *wiki* when collaborating with each other before and after the LEOS. While the students were familiar with the *wiki* because they already had an induction session during the second phase of this study, one of the two teachers was new to this pedagogical tool. However, the teacher was very keen to "give it a go" as she put it. The researcher emphasised that teachers needed to actively moderate *wiki* postings made by students.

The pre-visit preparation included both face-to-face classroom teaching and student groups collaborating via Moodle, hence it utilized a blended learning environment. The e-learning environment provided a different way of collaborating between students and between them and their teachers. Since the students were now familiar with *forum*, the researcher placed more emphasis on using *wiki* from the very beginning. After a week's work in class, the students groups were asked to use the *wiki* sites to discuss some of the questions and paraphrase the readings which were posted on Moodle by their teachers. These were used as a way of co-constructing knowledge in the embryonic stage which was subsequently refined afterwards as the study progressed. The Moodle sites contained a repository of video clips and literature articles from different sources for students to access and discuss using *wiki*. These were short videos showing the formation of the eight phases of the moon as well as lunar eclipse. Other articles were about the structure of the Moon, its discovery and the various phases, lunar eclipse, apogee and perigee of Moon (Apogee and perigee refer to the distance from the Earth to the moon. Apogee is the farthest point from the Earth. Perigee is the closest point to the Earth and it is in this stage that the moon appears larger) and how Moon affects tides on Earth (see Appendix D)

Classroom observations suggested that students were keen on sharing both ideas and responsibilities when working as a group, both in classrooms and on Moodle. The subject teacher, Ms. Clare had grouped students based on gender, ICT and leadership abilities. The diverse ability grouping ensured both sharing of responsibilities and members supporting each other. One student remarked that "co-construction of knowledge helps ensure that the members remain focussed on the concept which we will be tested in our internal assessment"(Student Interviews, 15 September, 2014).

Even though the students were instructed to use the *wiki* activities on Moodle to collaborate their findings from the readings, it was interesting to note that students quickly opted to use *forum* instead. Discussions with students suggested that because they were familiar with *forum* from the second phase of the study, they continued to use it.

Below are some *forum* postings made by students, which show a shared understanding of the different concepts. These postings also indicate that they were actively trying to help each other conduct joint research, the collaborative feature that characterises the appropriate use of *forum*. The only difference is that they were asked to use *wiki*, which they chose not to use (all names are pseudonyms).

Key Information

by Kyla - Monday, 29 September 2014, 10:19 AM

I was greatly impressed to learn the earth orbits around the sun in an oval not a circle.

Has an impact on the seasons we have.

Do any of you others have key findings?

Edit | Delete | Reply

Re: Key Information

by Bree - Monday, 29 September 2014, 10:21 AM

Yes it's very good what you're bringing in very suitable...

Don't know whether I could add much but I was intrigued in the matter of equinoxes and how they help to measure where stars are in relation to them.

Show parent | Edit | Split | Delete | Reply

Re: Key Information

by Susan - Monday, 29 September 2014, 10:23 AM

that's very good Bree

we could research that topic in depth to clear your doubt on the matter.

Re: Key Information

by Heidi - Monday, 29 September 2014, 5:30 PM

I've got books from the library...I only looked for ones that only had things about the phases of the moon, eclipses, and tides (which there was'nt much of...in fact v. little on tides)...only the stuff that we are allowed to write our reports on.

Show parent | Edit | Split | Delete | Reply

Re: Key Information

by Suzy Clare Tchr - Tuesday, 30 September 2014, 10:01 AM

I am truly impressed with the terms exchanged between the members. There are resources on the 11 SCIENCE GENERAL SITE which may be useful. It also includes video clips to help you learn about the celestial bodies and how they interact to cause tides, eclipses and different phases of the moon.

Figure 6.10: Summary of dialogues on *forum*, pre-visit

As seen from Figure 6.10 above, the students decided to continue using *forum* for group discussions instead of *wiki*. Interviews with students suggested that they used this because they were familiar with this activity. One saying that "I just did it because I forgot what the teacher had said" (Student Interviews, 30 September, 2014). Another student said, "I saw the posting and so I replied." This was, however, not what the researcher and the teachers had intended from this part of the study.

The researcher discussed with the teachers, who agreed that to make students collaborate with each other to co-construct knowledge, they needed to make *wiki* postings *compulsory* and students must use the *print-friendly page* of *wiki* as evidence in their final report to show that they had processed their researched information and then shared via *wiki*.

6.5.2 Integration of Wiki During Pre-Visit Preparations

Unlike the second phase of the study, where the teacher invited members of the Regional Council to introduce the topic, in the last phase, the first classroom lesson was conducted in the computer suite where the teachers used video clips to show the position of the three celestial bodies and how they interacted with each other. After students watched a video clip on their computers using their head sets, the teachers asked them to regroup and discuss what they had learnt. The groups then presented their findings to the class. At the end of their 2 minute presentations, the teacher encouraged other students to ask questions to the presenters. This allowed students to share their findings and also come up with questions which they wanted to explore further. After four of these types' of lessons, students started to show awareness of what they wished to investigate for their internal assessment. They had to choose 2 out of 3 possible astronomical cycles; the spin of the Moon, the orbit of the Moon around the Earth, and the interaction of the Moon and Earth orbiting the Sun. They had to relate the 2 cycles to only 1 effect on planet Earth. The 4 possible effects to choose from were "Formation of Tides, Neap and Spring Tides, Phases of the Moon and Lunar Eclipse".

Before visiting the ISI, an *Observatory*, the teacher wanted to make sure that students had some idea of which astronomical cycles and the possible effects on planet Earth they wished to explore. Below is a sample of one group's collaboration using *wiki*. The students postings in the figure given below show that they were keen to study Phases of the Moon. The sharing of information on the same topic pre-visit shows co-construction of knowledge which is one of the attributes of *wiki*.

Phases of the moon

There are eight (or nine) phases of the moon that are:
1) New Moon - Dark, not visible
2) Waxing Crescent
3) First quarter - half moon
4) Waxing gibbous
5) Full moon - see whole circle
6) Waning gibbous
7) Third quarter - other half-moon opposite to the first quarter.
8) Waning crescent
Back to new moon is a full cycle.

From the Earth, we can only see the part of the moon that the sun illuminates because we see it at different angles as it rotates around the Earth.
Also apparently the moon's cycle affects our emotions, mood and behaviour - I'm not sure whether that's a bit silly to add in!!

Re the Earth's orbit around the Sun...
The Earth is closest to the sun on January 3rd and this point in the Earth's orbit is called perihelion.
The Earth is farthest away on July 4th and this point in the Earth's orbit is called aphelion.

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the phases of the moon are regular & predictable, they are not just random!
the moon only rotates on its axis once per month, hence we only see one side of it.

Figure 6.11: Summary of dialogue on *wiki*, pre-visit

Additionally, in this part of the study, the teachers encouraged students to bring text books and other web-based resources from their local libraries. Interestingly, this was very popular, with students readily seeking out sources of knowledge. One student, for example, said "my father has a book on astronomy which I will bring for my group". Another student commented that "I will bring a video on tides and moon which my dad brought from overseas." These types of responses became part of most of the lessons and student discussions in the computer rooms were followed by postings on *wiki*. The students seemed pleased when they were told by their teachers that they were visiting an observatory, and were excited about the opportunity to discuss their questions with a local "astronomer".

The researcher tried to find out what discussions did the teacher have with the ISI staff during the planning of this LEOS as well as his background in the subject area. Mr. Daniel (a pseudonym) agreed that pre- and post-planning was very important "if one wanted to achieve the maximum learning from such visits"(Field Notes, 01 October, 2014). He said that he was not an astronomer, but belonged to a local group of star gazers who kept in touch with astronomers all over the world. He added saying that he has had several sessions on this topic before and was equally passionate to share his findings with students from *Rural High School*. He had a teaching qualification but had left classroom teaching some 30 years ago. He then joined the observatory as a science educator, and had been working with them ever since. He did not have a telescope at his home but used the one at this observatory with his star gazing team. He did, however, comment that he had a friend who lived in the country and who had a telescope. Every year he spent some time during winter with his friend "catching up and discussing objects beyond Earth (ISI Staff Interview, 01 October, 2014)."

The researcher identified that the ISI staff placed a strong emphasis on pre-planning, and in particular how he used pre-visit interactions with the teacher to plan the activities on the day of the visit. He strongly believed that it is not only watching films and listening to Power-Point presentations, but having hands-on activities as well as making personal inquiries would help advance students understanding of the different concepts in astronomy.

The excerpt given below is a discussion between the interviewer and ISI staff.

Interviewer: What contact did you have with the teacher before the visit?
Mr. Daniel: The teachers have made several contacts with me via telephone as well as through email correspondence to ensure that all objectives of the lesson were covered in my presentation. They had read from our website on the types of sessions we conducted and how long they were.
Interviewer: So what activities have you planned for them?
Mr. Daniel: The teachers want me to discuss the types of telescopes which are used to view celestial bodies. Also, they want me to show videos on the effect of Moon on tides, as well as rotation and revolution of the Earth around the Sun. I have also booked in the telescope room for them, where they will see and use a real telescope. We will use it to see the Sun, so I have to put a filter in.
Interviewer: So where would they be watching the video?
Mr. Daniel: Well, we have a classroom where the students will watch the video and it will also give them opportunity to ask me specific questions. The teachers told me that students have made some questions which they wanna ask me. However, in the planetarium, they will experience what it is like being beyond Earth. Students will sit in a theatre, and using a dome shaped ceiling, I will be projecting a special show called “Two pieces of glass”. We do not allow any electronic devices into this room. No photography is allowed here.

Interviewer: Wow that sounds really exciting. Are there any other activities planned for the day?
Mr. Daniel: Yes, from past experiences, I have found that students enjoy their visits to the observatory. We also have hands-on activities in the foyer which students should visit during their interval periods. It is like being in an Exscite Centre [a local interactive Science Museum] where you have set ups which require students to solve problems either individually and/or as a group. There are also computer programs which students could use and explore topics of their interest. I will be around if they wish to ask me any questions.

The teachers were also looking forward to this particular LEOS. Interviews with them suggested that they found it very difficult to conduct practical sessions on this topic, and so they were highly dependent on the ISI to help the students'.

Interviewer: How did you help students learn this topic last year?
Ms. Clare: Well, we cannot do any experiments and so it was mainly reading materials off the web pages. I also had some video clips which I had downloaded from YouTube which I used in the classroom
Interviewer: Did you find students keen in learning this topic?
Ms. Clare: To tell the truth, no. They were not keen because there were no experiments to do and our students here, love to be little scientists and enjoy working in the lab.
Interviewer: So if that was the case, then do you think that lack of engagement could have affected the types of reports they wrote at the end of the topic, last year.
Ms. Clare: Of course and also students mainly paraphrased the literature they read on the Web. Actually, the pass rate for this standard was not as good as we wanted in the last couple of years. It will be great for the students to visit the observatory this year.

Rural High School Year 11 students had never visited this ISI before as a class trip. One teacher reported saying "Astronomy is a subject which you can only appreciate if you use a telescope to view the world beyond Earth". In the past, students researched the topic using web-based resources to complete their assessment. This year, both students and teachers were keen to visit an *Observatory* to learn about Astronomy.

For this standard, the two teachers planned to create an integrated learning experience for their students. They created a blended learning environment by putting some teaching resources, such as video clips and literature materials as discussed above on Moodle, as well as planned a visit to the observatory. At the same time, they wanted to encourage students to use *wiki* for group collaborations both before and after the visit. They were also keen to find out how changes in their teaching approach would affect students learning outcome. Ms. Clare was reported saying that "I really want to see the number of student achieving at NCEA Merit and Excellence levels this year compared to last year".

Interviewer: So what changes have you made in your teaching plans this year?
Ms. Clare: I have grouped students up like I did last year. But the differences are that

they are using *wiki* to collaborate and also we will be visiting an observatory.

Interviewer: How do you think the use of *wiki* will affect students learning?

Ms. Clare: The students will read the literature I have put on Moodle and help co-construct each other's knowledge. In this way, they are learning from each other but I will moderate the post to make sure that they are saying the right things.

Interviewer: What about the visit to an observatory; How do you think that will influence the students?

Ms. Clare: This will give them opportunity to discuss their group questions as well as collect information on the topic they wish to research on for this standard.

This standard was planned to be taught over a period of four weeks. Before the lessons began, Ms. Clare contacted ISI staff to book the trip and discussed the objectives of the visit. She also made an application to the Deputy Principal for this visit which was approved the same day. Ms. Clare liaised with the school office, and made sure that consent forms were ready for distribution in the first week of teaching this standard.

The first week was an introductory week where the integrated learning model was shared with students. Week two was used for planning this LEOS and visiting the ISI. During this week, the teachers made sure that they liaised with the ISI again and informed Daniel of the specific objectives of the visit and intended learning outcomes. Week three was used to consolidate the findings from the ISI and other web-based resources using *wiki* while the last week was used for writing the final report under examination conditions.

During the first week of this topic, the students were informed on the importance of using *wiki* for collaboration between their groups before and after the visit. They were asked to submit the *print friendly sheet* with their final report. At the beginning of week two, they were supposed to confirm with their teachers which two astronomical cycles they were exploring. This enabled the teachers to regroup the students, so that the students could work together on *wiki* to research a common topic and help co-construct knowledge. It also gave them an opportunity to construct questions which they wished to pursue with the ISI staff. They were also allowed freedom of choice if they wished to pursue any other topic of interest at the ISI.

Some of the questions constructed by students were:

- How much does it cost to make a journey into space?
- What type of training do you go through when preparing for space travel?
- Besides the government, which other organisation funds research into space?
- Are there extra-terrestrial bodies out there? And
- What would happen if the Earth stops spinning? Will it fall off its orbit?

The student grouping changed after they had explored the different astronomical cycles and effects on Planet Earth in the first week of their study. At the beginning of week 2, the teachers circulated a sheet during the classroom session where students had to write their choices. Based on similar topics of interest, the students were regrouped. Each group of students was made up of eight participants, characterised by diversity in gender, academic ability and experience in NML. Two groups of eight students in Year 11 (15 years old) were told about the purpose of these interviews, most of these were the same students who were interviewed during the second phase. They were asked 10 questions (see Appendix L) and allowed adequate time to respond to each question.

The researcher discussed the purpose and perceived value of the visit during the focus group interviews before the visit, excerpts of which follow (all names are pseudonyms). It could be perceived from the discussions that while students were excited about the trip and shared similar reasons as was noted in the earlier phases, the responses during this phase of study are more reasoned though. Especially when they were questioned on concepts related to their study.

Interviewer: What is the main purpose of this visit?
Beatrice: To learn about how the Sun, Earth and Moon interact with each other.
Bryar: To learn about how to use a telescope to see the world beyond Earth.
Interviewer: So how do you think the three bodies are linked?
Beatrice: It’s their sizes and the gravitational pull is what they have on each other.
Interviewer: What are some of the things you enjoy about LEOS?
Brodie: We will be travelling for two hours each way and so we can stop over and have KFC [Kentucky Fried Chicken] on the way. That will be awesome for lunch.

Granger: I have been to an observatory before and I love the sound effect and the screening of the film up on the dome ceiling. It feels so real and you really feel that you are in space. It will be cool to see how the positions and angles of the three celestial bodies to each other create the eight phases of the moon.

Jed: I like to visit the observatory because I was told by the teacher that we could use models to actually see the eight phases of the moon. I also want to learn how tidal bulge is caused by centrifugal forces of the Earth's spin and gravitational pull from Moon and or Sun.

Interviewer: OK, but do you think there are things which should be changed? Why?

Drew: Yes, I think we should come at night and do the star gazing. We cannot see the stars during the day.

Brodie: May be we should also stay overnight.

The use of *wiki* played a pivotal role during group collaborations both before and after the visit. The researcher discussed the purpose and perceived value of the using *wiki* during the focus group interviews before the visit, excerpts of which follow.

Interviewer: Can you tell me what activities have you done before the visit?

Bree: We have collaborated on *forum* with other members in our team, but our teacher wants us to use *wiki*. So we have been using *wiki* more and now we know which astronomical cycles we wish to pursue.

Bianca: Well our teacher said that after visiting the observatory, if we wanted to change our topics we could, but we have to tell her before the end of the week so that she could regroup us.

Interviewer: Can Moodle be used to collaborate between students?

Joseph: Yes, we add information to what other members in our team have written.

Heidi: Yes, we have a leader and she makes sure that we are all contributing. *Wiki* helps to engage all students and she keeps a check on us also. So we have our teacher and now our group leader who helps us, which is so good.

Interviewer: Do you think *forum* and *wiki* sites can help you learn the topic better, if yes how?

Jed: Using Moodle site we can watch the video clip and visit websites and then share our findings with our group using *wiki*. It helps us to comprehend the information better. It is not just copying from the resources.

Granger: Everyone gets the help at once. If we have a difficulty understanding a paragraph from a page from the Web or have problems interpreting a graph, we ask our group members and we get instant feedback, this is so helpful.

Jed: Sometimes someone else has asked the same question you wanted to ask, and so you just go to the *wiki* and read the answer there. It is good because it is already written.

Logan: If you don't agree with someone's answer, you can write something more or different and provide the link where you got that information from. In this way we are developing a better list of references. Our teacher wanted a list of reference included in a final report.

Drew: Our teacher said that if we are arguing a point, we have to provide the link where we got this information from. She also wants us to have more references. So using *wiki*, everyone is collecting information from different sources, and together we get a list of references. We should certainly get good grades, man. But, I am so looking forward to our trip tomorrow.

The students clearly felt supported by each other when working as a team on Moodle. They certainly expressed the desire to continue using *wiki* even if initially compelled to do so, because they could share their understanding as well as ask each other for help on interpreting information from different sources which they had found difficulty with. Also, they felt that working on the same topic on *wiki*, helped them develop a common understanding which they supported by providing links to these resources. The students liked having a group leader who made sure that everyone was making contributions on the *wiki*, and having a mixed gender group was helpful. One student commented "The girls are very good at reading and explaining what it means while the boys are good at interpreting diagrams and graphs. And so we tend to help each other by making more posts on *wiki* (Student Interviews, 30 September, 2014)."

On Wednesday, 01 October 2014, at 6.00 am, a group of 64 students with 4 teachers departed *Rural High School* in their school bus for a two and a half hour long journey to the ISI. After a long journey through heavy traffic, singing students and speeding motorists, the bus arrived at the observatory. The staff and students were greeted by Daniel and another lady who was introduced as "a student in training". After recording attendance in the car park, the group was invited inside the building.

6.5.3 Activities Carried out During the Visit.

It was at 8.45 in the morning when the students assembled in the foyer of the observatory for a briefing. The ISI staff asked the teachers to divide the students into two groups and each group was accompanied by one ISI staff and two teachers. Mr. Daniel, ISI staff, told the group that "while one group was visiting the planetarium to watch the show on *Two pieces of glass*, the other group would have a classroom session". Both these 90 minutes sessions ran concurrently. The first group of students entered the planetarium which was a dark room with a dome shaped roof. The students were told to sit with their group members. As the students lowered themselves into the chair, they realised that the chair had a lower back and so they were nearly lying on their back facing the ceiling. This brought a lot of laughter and excitement and at that moment, they were told be "very quiet and to switch off all electronic devices". It took a while before the room became quiet. Each teacher positioned themselves on either side of the room before the show began. The show was about the discovery of telescope by Galileo Galilee in 1610. The story also covered the different types of telescopes and what they were used for. More slides followed on the different constellations and how they were used for navigation. The last part of the show was about the three celestial bodies, the Earth, Sun and Moon, and how they interacted with each other to create the different days, months and year.

While half of the students were watching the show in silence, the other half were in a classroom, where the trainee ISI staff used Power-Point and video clips to discuss the different types of telescopes, interaction between the Sun, Earth and Moon, phases of the moon, as well as tides (Neap & Spring). The students were given opportunities during the presentation to ask questions. It was pleasing to note that these students were not shy. Nearly all students volunteered to participate in the role play, but only three were called up on the stage to model how the three celestial bodies orbited each other (Field Notes, ISI visit, 01 October 2014). It was during this part of the session, when students asked questions which they had put together as a group. While these questions were not directly related to the internal assessment, the students nonetheless seem curious to know more about the place and how it operated. One student asked "Besides the government, which other organisation funds research into space?" The ISI staff replied, "Some work is also funded by private business companies and even universities". One of the students then inquired, “Are there extra-terrestrial bodies out there?” The ISI staff replied: "You never know. Maybe we just haven’t come across them at present (Field Notes, ISI visit, 01 October 2014).”

The students were observed to be working in their groups and writing information, which they thought was relevant for their internal assessment (Field Notes, ISI visit, 01 October 2014). There were a number of Websites quoted during this presentation and the ISI staff agreed that they would send them via email to Ms. Clare. They also agreed to accept emails from students if they wished to make further inquiries of concepts which they found difficulty in understanding. At 10.30am, students were allowed interval time. They explored the exhibits in the foyer. At 11.00am, students from planetarium attended the classroom session, while the group which was in the classroom visited the planetarium to watch the show. Both sessions concluded at 12.30pm. Figure 6.12 shows some of the exhibits students used for learning.

Figure 6.12: Observatory foyer exhibits and interactive learning amongst students

At 1.30pm, one group was invited to the room where the telescope was kept while the second group continued exploring the exhibits. The session’s alternated after half an hour for the second group to do the same. In the telescope room, the students were shown the different parts and functions of a telescope. The ISI staff opened the dome and placed a light filter on the lens so that the students could view the Sun. This was the highlight for many students because most told the researcher that they had never used a "real telescope before (Field Notes, 01 October, 2014)."

At 2.30pm, students assembled in the classroom, where some managed to find seats while the rest remained standing. While one ISI staff distributed evaluation sheet to each student, the other presented a summary of events of the day. He also asked the teachers to submit evaluation sheets at the reception. Mr. Hoyle, asked a male student to thank both ISI staff on behalf of the group, which was followed by spectacular applause. At 2.50pm, Ms. Clare managed to collect most of the completed evaluation sheets, and left them with the reception. The students then boarded the bus and returned to their school.

6.5.4 Post-Visit Activities

After the students had left with their teachers on the school bus, the researcher approached the ISI staff, Mr. Daniel to discuss the visit. He was very keen and invited the researcher to his office. At this time, the trainee staff had left and so she could not be approached. The researcher tried to find out how the ISI staff had used his findings from liaising with the teachers to prepare for the activities carried out by his staff and himself at the observatory. It appears that the ISI staff were impressed by the prior knowledge students brought, and also willingly participated during classroom sessions. The excerpt given below is a discussion between ISI staff and the researcher (all names are pseudonyms).

Interviewer: How do you think the visit went?

Mr. Daniel: I was pleased with the questions these students asked. It showed that they had done their findings before they arrived. This cannot be said about other schools I have had before.

Interviewer: What do you think the students learned?

Mr. Daniel: I think that the students realised that all celestial bodies have an effect on each other. I tried to show this in three ways, using slides, video and role play in the classroom. It is the size, distance and angle which determines the effect it will have on the cycles on Earth.

Interviewer: How do you think they have learnt that?

Mr. Daniel: I tried to reinforce these concepts using three different teaching methods, something which teachers do in the classroom, if they want their students to remember and understand something new.

Interviewer: How do you know they have learnt that?

Mr. Daniel: They asked me questions, and also if you remember they also added to what I shared in my classroom presentation. The girls seemed equally determined to share what they knew about the topic. I am impressed.

Discussions with Mr. Daniel also suggested that he was impressed with students on task behaviour and the willingness to participate during role play. He was surprised to note that this was the first time that *Rural High School* Year 11 students visited this observatory. He however cautioned the researcher saying that "not all what students read on Web sites is true, and so students should be made aware of this". He was willing to be in touch if the researcher wanted to make further contacts.

The following day, the researcher met with the teachers for informal interviews at school. The researcher tried to find out how pre-planning and liaison with ISI staff affected the events of the day. Both teachers decided to sit in together for the interview because they were otherwise very busy for the rest of the day. They also informed the researcher that they had a short briefing at lunch and a Departmental meeting in the afternoon. The excerpt given below is a discussion between the teachers and the researcher.

Interviewer: How do you think the visit went?

Ms. Clare: The presentations covered all different concepts that we are studying. I was pleased to note that Mr. Daniel used PowerPoint, role play and movies to communicate information. The students really enjoyed it, and so did I.

Mr. Hoyle: I agree. I liked it because every time he presented a concept, he discussed it using real-life examples. This is what students want to know and it makes it easy to understand. The trainee staff also gave brochures and a list to Web addresses to students, which will help them in their research, love it.

Interviewer: How do you know that students will make use of this information?

Ms. Clare: The activities were specifically designed to cover all concepts which we had asked for. I am so pleased that they both made the sessions interactive and students willingly asked questions. Even the trainee did a fabulous job. They were both very friendly and enthusiastic, which the students liked.

Here the researcher tried to find out how teachers perceived the value of activities presented by the ISI staff. The discussions suggest that they were pleased with the order of the presentation, as well as the nature of the personnel made learning more interesting to both teachers and students.

Interviewer: How do you think the afternoon session went?
Ms. Clare: Daniel was very clever in the way be designed the activities for the day. Even though I had asked him to show the telescope in the morning session, he kept it for after lunch. I now see why.
Interviewer: Why do you think he did that?
Ms. Clare: The morning session was more targeted around the concepts he wanted to cover and students were more energetic and engaging. After lunch and play on the flying fox, they became slightly 'more excited' [delayed response]. So having a hands-on activity was much better.
Interviewer: What do you think your students learned?
Mr. Hoyle: The students surely could see that the three celestial bodies interacted with each other, which strongly influenced the effects on Earth.
Interviewer: How do you know the students learned that?
Mr. Hoyle: More than half the class is doing their project on phases of the Moon and its effects on planet Earth. This was something that was thoroughly discussed during the visit. Also, the websites which were provided had lots of information for students to use. The *wiki* postings are interesting to read, and comment on also.

The researcher was interested to find out how the two teachers perceived this first visit to the *Observatory* and also if there was any opportunities for free choice learning.

Interviewer: Was there any free choice learning included when planning for LEOS?
Mr. Hoyle: The LEOS was a great idea because it allowed students better

understanding of the topic they were pursuing. The ISI has better facilities and well trained staff in this area. While Ms. Clare and I have our science degrees, we have not done this subject at university. It is always good to have a specialist share their skills with our students. About free choice learning, they could choose any of the topics which we gave them and they were told that if they wished to change their group after the visit, they could do so. Also, they had their own questions they had put together as a group to ask the ISI staff.

Discussions with the teachers thus suggested that they were pleased to have made this visit. They also acknowledged that their own lack of knowledge and skill in this area was overcome by having specialists involved who were using targeted activities and specialised tools for integrating learning. They had allowed for some free choice during LEOS which was well received by students. They agreed that *wiki* allowed for more student collaboration as well as students taking ownership of their learning.

On the same day, the researcher met again with the students, and held focus group interviews to discuss the visit. Here, the researcher was interested to find out how students perceived the LEOS. Student feedback suggests that LEOS certainly had a positive effect on their understanding of the various concepts which some of them had struggled with. The excerpt given below is a discussion between students and the researcher.

Interviewer: Did you enjoy the visit?
Granger: It was awesome. I really enjoyed watching the movie in the planetarium. Also the slide shows on the dome were impressive.
Interviewer: What do you think you learned?

Drew: I learned about how telescopes are used to view objects beyond Earth. Also, how the Sun, Earth and Moon interact to create seasons, day, night, month and year.
Interviewer: How did you learn that?
Jed: We were showed movies and also in the classroom, the presentation helped me learn how these three celestial bodies interact. I especially enjoyed learning about the eight phases of the moon.

Brock: The guy [i.e. Mr. Daniel] was good. He related to things around us which made it more interesting. Also, it was the first time I had used a real telescope. Watching the Sun using it was fun.

Interviewer: How do you know you learned that?

Brad: I can now explain to members of my group things in more depth. Before, I used to read the articles and paraphrase it before I made a posting on *wiki*. At least now I can justify my answer and equally link it to other literature, graphs and diagrams I have read.

Interviewer: What activities were done after you all returned from the site visit?

Lily: We had to discuss our findings from the visit and add it to our group postings using *wiki*.

Students actively seek each other support in understanding the information they had collected from the visit to the observatory. The discussion between members of one of the groups, post-visit via *wiki* is shown in Figure 6.13 given below. The information describes students helping each other to co-construct knowledge.

Printer-friendly version

Phases of the moon

the moon moves across the sky about 15 degrees per night

when the sun & the moon are on opposite sides of the earth, it is full moon.

- There are eight (or nine) phases of the moon that are:

1) New Moon - Dark, not visible

2) Waxing Cresent

3) First quarter - half moon

4) Waxing gibbbous

5) Full moon - see whole circle

6) Waning gibbous

7) Third quarter - other half moon opposite to the first quarter.

8) Waning cresent

Back to new moon is a full cycle.

- the phases of the moon are regular & predictable, they are not just random!

- the moon only rotates on its axis once per month, hence we only see one side of it.
- The Earth is closest to the sun on January 3rd and this point in the Earth's orbit is called perihelion.
- The Earth is farthest away on July 4th and this point in the Earth's orbit is called aphelion.
- The way to understand the phases of the moon is to think about the position of the sun as it is what shines in the moon to create a 'day' side.
- ALL CELESTIAL BODIES RISE IN THE EAST AND SET IN THE WEST DUE TO THE SPIN OF THE EARTH
- Because the moon is moving 12-15 degrees each day, the Earth has to rotate a certain amount more to catch up, so therefore the moon rises about 50 minutes later each day as it appears in a different part of the sky at each night. This was discussed at the observatory.
- The Apogee is the farthest point of the moon from the Earth and makes it appear smaller than when it is at the Perigee. (closest point from the Moon to earth) When the moon is closer to earth, (PERIGEE) the gravitational pull is much more so there are higher tides and more variation in the difference between low and high tides. It was interesting to note that Daniel said this is the reason for high tides at the Auckland shores instead of what the media reported. The media reported that due to global warming, the sea level is rising which caused the nearby playgrounds at Auckland seashore experiencing flooding.

-B

Must include the linking of the moon's rotation (only see one side of moon) and orbit (position moving to see differing amounts of moon) around earth contributing to the different phases. **Teacher**

In the Southern hemisphere, before the full moon, the left side of the moon is lit. After the full moon the right side is lit, this is opposite for the northern hemisphere. When the sun and the moon are on opposite sides of the earth, it is full moon
When they are on the same side, in alignment, it is new moon
S

Also called **lunar month.** The period of a complete

revolution of the moon around the earth, as the
period between successive new moons **(synodic month)** equal to 29.531 days, or the period
between successive conjunctions with a star **(sidereal month)** equal to 27.322 days, o r the period between successive perigees **(anomalistic month)**equal to 27.555 days, or the period between
successive similar nodes **(nodical month or draconic month)** equal to 27.212 days.
ask me for the referencing of the definitions above at school...

- Synodic Month: 29 d, 12h, 44m, 03s
- measured new moon to new moon, and this time is referred to as lunation.
- 2.21 days longer than sidereal month, because moon must catch up in it's orbit to begin in same position relative to the stars.
- center to center distance between moon and earth:
- at apogee: 405,504 km
- at perigee: 363,396 km
- Anomalistic month (mean): 27d, 13h, 18m, 33s.
- Anomalistic: typically within 1 day of mean value, but every 7-8 months, significantly shorter than mean by about 2-3 days.
- Anomalistic: varies, and variation longer than lunation
- Draconic Month: one revolution of the moon about it's orbit with respect to the ascending node.
- Draconic: 27d, 05h, 05m, 36s
- can vary by over 6h from mean time.
  mean is 2h, 36m, 36s shorter than sidereal month.

Fig 6.13: Summary of dialogues on *wiki*, post-visit

The researcher further discussed with the students what they perceived to be the benefits of collaborating via *wiki*. It was interesting to note that students were keen to discuss their findings, and also thought that they could easily justify by providing websites, which other students could explore. They could also interact at any time of the day and equally from home and draw upon each other's strengths, especially when interpreting diagrams and graphs. The excerpt given below is a discussion between students and the researcher.

Interviewer: Can Moodle be used for collaboration between students; How?

Bianca: It is a very effective way to share ideas with each other in the group. You also know that people making postings have researched the topic because they will be using the *print friendly page* to write their final report. So it benefits everyone. We also know that the teacher will correct and guide us if we are not thinking deep enough.

Heidi: It's great because we can check it at any time using our devices, and any posting we make helps to engage all in the group. It also enables us to note the differing points of view and how these are justified.

Kyla: Moodle helps us to develop a better comprehension of the topic we are studying. We read the literature provided by our teacher, then after visiting the observatory, we have now developed a better understanding of the literature. I had difficulty understanding how Moon affects the tides on Earth. But now I can discuss this with my group members. Even the graphs on tidal movement and diagrams make sense.

Drew: I like collaborating via *wiki* because the students and the teacher provide a timely correction if I had said something wrong. This helps me because then I can start thinking the correct way. I can also read other students postings to verify what I need to know. It is an effective way to share your findings and at the same time realise how much you know about the topic.

Jed: I now understand the difference between *forum* and *wiki* which I had never heard before. *Forum* is good to share different topics, while *wiki* helps you to discuss the same topic and develop a deeper understanding. I like the *print friendly page*. It will help me in my final write up.

The researcher found that the trip to the *Observatory* was helpful in enhancing the students understanding of the different concepts in this standard. While students had the opportunity to watch video clips on Moodle and read the literature, the visit to the ISI provided deeper understanding. The students reported that videos and literature on their own was difficult to understand. However visiting ISIs and interacting with ISI staff appeared to have made learning more interesting and meaningful. The students also expressed great enthusiasm for collaborating using *wiki*. This allowed remote access to discuss the same topic in groups, and also get timely feedback. The presence of their teacher was reported to be reassuring in case the students made any mistakes. Additionally, since everyone in the group was using the *print friendly page* to write their final report, they all wanted to do their best and collate the best set of notes, to help them complete their finals under examination conditions.

When the students returned to school after the visit, they were given a week to collate all data and research materials from the websites and use them to complete their report. During this time, the teachers used both classroom sessions as well as the *wiki* sites on Moodle to help extend the students' knowledge on astronomical cycles of the Moon and their effects on Earth They were given two hours to complete the written report under test conditions. These reports were marked using the answer schedule put together by the Department, and a sample of the paper was moderated to check consistency in marking (see Appendix T). The assessments results will be discussed next in Section 6.5.5.

6.5.5 Student Assessment Results

The assessment task used this year was similar to the one used by the Department last year. However, the differences were in the way the standard was shared with the students. This year, the Department had decided to make a trip to the observatory, as well as include other pedagogical tools such as the use of *wiki* in co-constructing students' knowledge. It was also highlighted by the HoD during the interviews that they wanted their students to become "assessment capable". This meant that student could reflect on their work and correct any mistakes which they may have made. This was evident from *wiki* where students were correcting each other's postings. To allow for freedom of choice in learning, the students could choose one topic from the variety of topics given (see Appendix D) and they were also allowed to change their groupings after visiting the observatory if they found another topic more engaging. They were asked to explore questions of their interest, which was not related to their internal assessment, developing ownership of learning.

This phase of the study integrated all three types of learning, formal, non-formal and informal, using *forum* and *wiki* as the digital technologies. The LEOS not only provided a different context for student learning, but gave them the opportunity to both prepare themselves pre-visit using *wiki* and also to collaborate their findings using the same medium, post-visit. Interviews with the students suggested that they found the experience rewarding, because it helped them to interpret the video clips, as well as graphs and diagrams better. In other words, the change in the teaching pedagogy allowed them to take ownership of their learning; the students appeared to have become assessment capable as they started to help correct each other's postings. This provided some evidence for the development of NML skills, an essential skill for students to develop in the 21st century where they can better interpret information from various different sources which are presented in different formats. It was also encouraging to note that students felt supported when using *wiki* as a platform for learning. They highlighted the fact that they could use the tool remotely, managed to get timely feedback, could check others ideas, and also collect a catalogue of reference from the *print friendly page* which would earn them "a better grade for their final report". The experience at this phase of the study appears to have been rewarding for both staff and students. The table below shows students' performance in AS90954 between 2013 and 2014.

Table 6.4: Summary of assessment results for AS90954: *Lunar- Our Moon,* between 2013 and 2014.

Year	Not Achieved	Achieved	Achieved at Merit	Achieved at Excellence
2014	0	13	35	52
2013	20	7	43	30

The student performance in the table given above shows a substantial improvement in their results for this standard over the period of survey. The HoD attributed this to the integrated learning model used for curriculum delivery. She stated that "the notes and videos on their own are not as effective as when students hear from ISI staff and collaborate with each other what they had learnt".

It was interesting to note that no one was unsuccessful in this internal assessment. The students who could not visit the ISI were reported saying that the collaboration on *wiki* was "very helpful, in particular the *print friendly page* to help collect information for their assessment".

6.5.6 Section Summary

This section summarizes the findings from third phase of the intervention study:

- AS90954 was not an easy topic to teach as well as the students lacked enthusiasm;
- Mixed gender grouping with a student leader helped ensure support for all members;
- Making the *print friendly page* of *wiki* compulsory maximised student participation;
- Introductory lessons which included presentations by students after viewing videos on Moodle followed by class discussions enabled them to choose a topic which they wished to research on;
- Students brought in resources from home and their local libraries to share with each other;
- Doing hands-on activities in groups at the ISI encouraged more dialogue, where they used their group questions to make inquiries with the ISI staff;
- The lessons prepared by ISI staff using Power Point, videos and role-play helped reinforce the concepts and retain these information for the assessment task;
- Students displayed well developed skills using both *forum* and *wiki* in particular;
- The ISI staff was passionate about what they did and reassured students that they could be contacted after the visit. They asked students to evaluate their presentation, which was different from both the previous phases of the study; and
- There was a substantial improvement recorded in student performance.

This phase integrated pre-visit and post-visit activities with classroom practice using *wiki* as the learning platform. It was encouraging to note that the teachers worked alongside the researcher and the ISI staff to include recommendations, which were made in the first two phases of the inquiry. The students displayed keen interest in collaborating via *wiki* and were equally overwhelmed by the positive outcomes which they experienced as a group.

The teachers were pleased that including LEOS and the use of *wiki* allowed for a deeper understanding and comprehension of the materials, which they had posted on the Moodle. The teachers reported that they were very pleased with the students' performance in this achievement standard. Ms Claire said "this was the first year that we have had no students failing this standard. It could be because of the new teaching approach we had adopted". Mr. Hoyle went on to say that "we will make sure that we take our students to the observatory if we continue with this standard next year". Interviews with students suggested that the third phase of the study allowed them to develop a better understanding of the features of *wiki*, and they found it extremely useful when learning together as a community. The results of these students show that not only had they performed better than the cohort in 2013, but there was evidence that use of *wiki* allowed the development of NML skills as well. Section 6.6 which follow, provide the Chapter summary.

6.6 Chapter Summary

This Chapter provided a description of the research findings for the second research question. To establish whether or not an intervention based on learning support provided by digital means had an effect on these desired learning outcomes, when evaluated against the New Zealand Curriculum achievement objectives.

The intervention was carried out in three phases. The first phase placed emphasis on pre-planning and post-visit activities during LEOS. The second phase included the use of Moodle as the LMS, in particular, *forum*, to allow collaborative learning while the third phase utilised a second feature of Moodle, called *wiki*, to enable co-construction of knowledge amoung students. It thus provides insight to the changes in teaching and learning practices pertaining to LEOS in three different standards namely AS90943, AS90926, and AS90954 at NCEA Level 1 Science at *Rural High School*.

The findings reported that while *Rural High School* did identify LEOS to have huge potential in enhancing student learning in science, there was lack of planning, almost no curriculum links and also no inclusion of free choice in learning when making these visits. In the first phase of the intervention, the findings reported a substantial improvement in collaboration between the teacher and the ISI staff, with more targeted and engaging activities for students. The teacher also included some free choice in learning opportunities which as appreciated by students. The classroom observations as well as students work displayed adequate planning for both pre- and post-visit activities which resulted in improvement in students assessment results for AS90943, *The Design Game: Keeping Your Home Warm*. While this was true, there was a lack of awareness on the affordances of Moodle for informal learning.

Therefore, the second phase of the intervention saw the induction of both staff and students to using two features of Moodle for collaboration and con-construction of knowledge when engaging LEOS. The results showed that students chose to taken up the use of one feature rather than two because they had no prior experience using Moodle for collaborative purposes. *Forum* was popular amongst students, which helped in pre-visit preparation and post-visit feedback. Again a relatively small, but a positive change in student assessment results was noted for AS90926, *Report on a Biological Issue*.

In the third phase of the intervention, the emphasis was on use of *wiki* and having the *print friendly page* as a requirement for the internal assessment report made students take up this feature more seriously. The classroom practices adopted a blended learning environment approach using *wiki* for both pre-planning and post-visit activities, resulted in a substantial improvement in student performance for this standard. An interesting 100% pass was noted in AS90954, *Lunar- Our Moon.*

It is therefore suggested that the potential benefits of LEOS, may be realized by integrating all three types of learning, formal, nonformal and informal, using a learning management system, such as Moodle. While this is true, it is equally important to emphasise the multi-faceted role played by the teachers in terms of ensuring adequate planning for pre- and post-visit activities, liaison with ISI staff as well as facilitating discussions on *forum* and *wiki*.

The next Chapter discusses and draws conclusions from the findings in Chapter 6.

CHAPTER SEVEN
DISCUSSIONS AND CONCLUSIONS

Overview of the Chapter

This chapter presents discussion and conclusions drawn from this inquiry, thus addressing both research questions. Section 7.1 begins with discussion of the findings for the research question one, which describes current practices involved in LEOS at *Rural High School*. Section 7.2 provides a discussion of the findings from the intervention phase of the study, which used an integrated learning model. Three achievement standards, namely, Physics (SC 1.4 AS 90943), Biology (BI 1.2 AS 90926), and Astronomy (SC 1.15 AS90954) were considered, and Section 7.3 provides discussions and conclusions with respect to the literature. Section 7.4 reports on limitations of the inquiry, and Section 7.5 presents the implications of these findings. Section 7.6 makes suggestions for future research. The chapter concludes with Section 7.7, which summarizes the key findings from this inquiry.

7.1 Discussion of Findings for Research Question One

The overall aim of this inquiry was to gain a better understanding of how LEOS might improve science learning outcomes. Research question one sought to establish if teachers' current practices in LEOS were effective in producing the desired learning outcomes for developing scientific understanding, evaluated against New Zealand Curriculum achievement objectives. As reported in Chapter 5, The School Handbook for *Rural High School* stipulated creating a learning environment, including styles and practices intended to maximize learning via a dynamic innovative learning environment. However, analysis of the findings for Year 10 students (14 years old) at *Rural High School* in 2013; indicated classroom practices mostly adopted traditional teaching and learning methods. The lessons were teacher dominated, with only limited use of ICT resources. Also, while the Faculty of Science agreed that LEOS had enormous potential for informal learning, where student learning was self-paced and self-directed, the practices adopted by these teachers showed significant lack of affordances for LEOS.

Nevertheless, the Head of Faculty, Ms. Harris, the Teacher-in-Charge, for Year 10 Science, Mr. Macdonald as well as other teachers in the Faculty of Science evidenced a strong disposition towards engaging in LEOS. The Faculty of Science teaching calendar also indicated numerous ISIs visited by students every year (see Chapter 5, Section 5.2). The teachers reported the LEOS selected for this study helped provide authentic contexts for learning where students had the opportunity to experience the fragility of an ecosystem by observing the effects of pest eradication at the *Island Ecological Reserve*. However, there was no assessment evidence to suggest what learning outcomes were achieved by the visit to the ISI. The same could be said for numerous other ISIs visited every year by students in both Years 9 and 10 (13 & 14 year old respectively).

It was concerning to note in Chapter 5, that the teachers involved in these LEOS had no input to the planning of the visits. It was Faculty-wide practice that the visits were planned by the Teacher-in-Charge at the beginning of the year, and usually the trips were to the same locations every year. The logistics of the trip only involved Teacher-in-Charge and the Deputy Principal. An email was sent to the HoF informing her of the event. Consent form distribution and collection of monies were handled by the School Office. The subject teachers did remind students of consent form submission dates during subject lessons. Therefore this lack of subject teacher input in planning, most likely limited the expected learning outcomes from these visits.

While the Faculty, as reported earlier, strongly believed engaging in LEOS could help enhance learning outcomes in science, the evidence suggested otherwise. LEOS was only offered to students in Years 9 and 10 which were conducted only at the end of the year. Several reasons were reported for the lack of LEOS integrated learning. These were lack of flexibility in the teaching calendar, and that students should not miss out on other curriculum areas. Other reasons were having very large class sizes, which required more teacher supervision, more meals, and transportation which would be expensive. It appears that a culture of not providing any LEOS at senior levels became the Science Faculty norm and teachers did not intend to bring any changes because they were already struggling with numerous responsibilities together with long working hours. The LEOS at the end of the year was then mostly to reward.

Rural High School was seemingly proud to have a Professional Leaning Communities (PLC) within the school, which focused on working interdependently to achieve a common goal for which members were mutually accountable. This group met routinely for 40 minutes on Friday mornings when the team members discussed issues and formulated goals and strategies for achieving them. Some of these issues were curriculum documents and schemes of work. The Scheme of Work which contained the Unit Plan (see Appendices H, I, J) for this part of the inquiry, outlined the achievement objectives, learning plan, thinking skills, values, social skills and assessment evidence. However, examination of the teacher's daily planning diary, classroom practices as well as students work books showed a lack of planning for both pre- and post-visit activities. Likewise, activities at the ISI showed no curriculum links, and that no student ideas were explored when planning the visit. There was then no provision for free choice learning. The planning and execution of the topic *Pest Ecology: Investigating the Rat Population in the Rural High School Community, and Pest Impacts on Island Ecological Reserve* was seen to be *ad hoc*.

The Teacher-in-Charge, Mr. Macdonald reported that he had informed the ISI staff in one of his emails of the activities he wanted students to carry out during the visit. He also agreed that he had not pursued any discussions with the ISI staff member, Mr. Linc, to ensure that the events were planned as was expected. None of the suggested activities were carried out on the day of the visit. Instead, a long introductory speech by Mr. Linc, emphasising the need for forest conservation, with two dichotomous questions over a 45 minutes period, did not much engage the students. Most of the students did not know what they were supposed to do during the visit and many constantly talked about the camping trip they had returned from a day before. It was also observed that students were not required to complete a post-excursion report which further contributed to the lack of student engagement. It can then be said that the last week of the schooling year was mainly used for camping and taking students on visits only to relieve teachers so they could attend to other school-wide responsibilities. While the staff ostensibly believed that integrating learning by engaging in LEOS helped enhance learning of science, no changes in planning were made even though several sites were visited annually.

It appears that while the School Handbook promoted the concept of providing a dynamic and innovative learning environment for students, there were no assessment results available to measure any learning outcomes, especially for this topic. Additionally, the staff agreed that ISI could help provide students with experiential learning experiences, which would increase motivation and informal learning, but the preparation for the LEOS before and after the visit was not well organised, because it could only be conducted at the end of the year.

The findings from this part of the study led to the following six recommendations:

- To maximize learning outcomes, LEOS should be facilitated by pre-planning and post-visit activities, all of which should be strongly linked to curriculum objectives;
- Students should be made aware of the learning activities for their visit to the ISI;
- Students should be involved in planning for LEOS, where their ideas are considered, and the trip must include some free choice learning;
- Trips to ISIs should be planned to run concurrently to the topic being taught in the classroom;
- To maximise student interaction during LEOS, the ISI staff should be informed of the objectives of the visit in order to prepare targeted activities, which enabled group discussions; and
- Features of Moodle, such as *forum* and *wiki* should be used to enhance informal learning, enabling collaboration between students and between students and teachers before and after LEOS.

7.1.1 Section Summary

In summary, while the School Handbook reported that *Rural High School* had an enriched learning culture, evaluation of classroom observations, teacher planning, student workbooks and interviews with all stakeholders suggested this was not so and that teaching was in fact rather teacher-centered. This pointed to a need to change ways in which the school had been planning and conducting LEOS.

As noted in Chapter 5, the *Rural High School* evaluated and reviewed its programmes annually with the aim of improving and refining goals, content, delivery, structure, and outcomes of the curriculum, in relation to student achievement. Therefore, better pre- and post-visit planning activities and integrating learning using a LMS, Moodle, became vital in achieving better learning outcomes when engaging in LEOS.

7.2 Discussion of Findings for Research Question Two

Research question two sought to establish if an intervention based on learning support provided by digital means (in this case Moodle – using *forum* and *wiki*) had any impact on desired learning outcomes when evaluated against the New Zealand Curriculum achievement objectives. Drawing upon the analyses of findings from Chapter 6, Section 7.2 presents discussion and interpretation of what was found from the three-phase intervention study. The first phase involved improvement in pre- and post-visit activities, the second phase integrated learning using *forum,* and the third phase included the use of *wiki* to help students' co-construct knowledge and develop NML skills.

7.2.1 First Phase of Intervention

During the first phase of the intervention, a stronger emphasis was placed on planning of pre- and post-visit activities. This phase was based on the strand called *Making Sense of the Physical World*, and the achievement standard used was AS90943, *The Design Game: Keeping Your Home Warm.* The intention here was to see if better pre- and post-visit planning improved the learning outcomes for this achievement standard. It appears from the findings that if any teaching approach helped produce a better pass rate, in this case more students achieving at Excellence level, then teachers would continue to use the same traditional classroom practices without making any evaluation. The fear of being judged by parents was a factor contributing to retaining such teaching methods, which produced accepted student pass rates, and thereby a more positive perception of teachers' performance.

Even though the School Handbook asserted e-learning formed an integral part of *Rural High School's* teaching and learning culture, research findings for Year 11 (15 years old) science students suggested otherwise. The BYOD program which was intended to help students make connections, overcome barriers of time and distance, and facilitate shared learning communities, was deemed a failure due to lack of devices and ownership of learning via digital methods. The staff and students were not familiar with the different features of Moodle. The first phase of this inquiry was then the first year for the Faculty of Science to use Moodle as a repository of resources. In the past years, students usually gained information from text books, work books and Web pages accessible through the school the portal. The staff did not use Moodle as a pedagogical tool, even though it had been available at the school for six years. Hence, the development of digitally-supported LEOS required familiarity with the tool. While most teachers agreed that ICT had considerable potential to support the teaching approaches, some teachers expressed concern over its use. One of the teachers saw it as a distraction to student learning, rather than as a way of supporting learning via digital means. Lack of staff professional development in e-learning as a pedagogical tool was seen as the primary reason for its lack of usage in classrooms.

Even after two workshops with all teachers of the Faculty of Science, it was difficult to recognise that they saw themselves playing a crucial role in student e-learning communities. For example, students' postings on *forum* had to be actively moderated in order to maximise learning through digital means. This was something of a 'foreign concept' to the teachers involved in the first phase of the inquiry. With constant checking of teacher planners, having several meetings at a time convenient to them and with several classroom visits, the planning for pre- and post-visit activities was well underway. It was, however, the two teachers in particular, their teaching philosophies and the fear of failing their students if they adopted an integrated teaching model, that failed to use *forum* in the first phase of inquiry.

LEOS influenced other teachers to adopt an integrated model that enhanced the learning outcomes for this achievement standard. There was strong evidence of pre-visit activities which were linked to post-visit outcomes. Constant liaison with the ISI staff helped ensure more targeted and hands-on activities for students, which were enjoyed by all. Also provision for at least some free choice learning allowed more collaboration between students and between students and the ISI staff. It was interesting to note that students spontaneously evaluated their findings and made suggestions on how to improve the visit if it was offered again the following year. This was an example of students taking ownership of learning, one of the reported outcomes of informal learning. Teachers expressed great enthusiasm about integrating LEOS with the classroom practice, as this they believed contributed to a substantial improvement in student performance in their summative assessment as reported in Chapter 6 (see Table 6.2).

There were differing explanations between the teachers and students for the lack of inclusion of digital technologies in classroom practice. As noted above, one of the ten teachers feared that the innovative approach might negatively influence student performance, which could potentially damage their careers, while students seemed keen to use this tool because they could communicate with their friends outside classroom hours. Other reasons noted were lack of professional development by the Senior Leadership Team as well as lack of devices and support from the ICT Department. It seemed odd that if these were genuinely the issues, then why were they not discussed during the weekly PLC meetings. The students on the other hand were not aware of the affordances of Moodle, purely because the school, despite having supposedly implemented this system for six years, had never inducted students to ensure its effective use. Moodle was instead largely used for administrative purposes at *Rural High School.* Therefore, it became necessary to involve the ICT Department and provide induction sessions with teachers and students, in order to create awareness on ICT integrated learning.

7.2.2 Second Phase of Intervention

During the second phase of the intervention, emphasis was placed on using digital technologies, such as *forum* and *wiki* to help support students learning for an achievement standard. This phase of the inquiry was based on the strand called *Making Sense of the Living World* and the achievement standard AS90926, *Issues of Protecting Biodiversity in New Zealand*. The intention was to see if digitally-supported classroom practice helped improve the learning outcomes for this achievement standard. It was evident from the findings that students were keen to share their ideas with others as they saw this as a way of finding out if they had learnt the topic. They were equally keen to use the LMS because they could access information from home.

The two teachers' interviewed in this phase of the inquiry were passionate about this topic and they were actively involved in the Enviroschool programs as noted in Chapter 5. This appears to have influenced the way they planned the delivery of this achievement standard. The inclusion of School Careers Advisor as well as accessing staff of Regional Council (RCT), who had expert knowledge on pest control, biological control and biosecurity, were two things different from the first phase of the inquiry. The HoD, Mrs. Lomas had worked alongside the Leader of the RCT, Ms. Audrey, on several Enviroschool projects before. This personal relationship made it easier to ensure more targeted activities were prepared for the visit. However, this was the first time Mrs. Lomas sought assistance from the RCT to help conduct LEOS for this particular achievement standard, but pre-planning was seen to be of great advantage. Both teachers were keen on engaging in LEOS, because they felt it helped provide students with opportunities to develop a personal connection with biological issues such as biodiversity and biosecurity.

These two teachers, Mrs Lomas and Mr. Gibbs also had a good level of computer literacy skills, and so were early adopters of integrating learning using digital technologies. Creating a blended learning environment from the first day, thus helped establish a culture that was lacking in the first phase of the intervention. Students were taught in the library, which had a classroom and an adjacent computer suite. While the classroom was used to help students learn the biological concepts, interactive discussions were encouraged using *forum*. There were also occasions, especially before the ISI visit, where the two teachers combined their classes in the library. After discussions in the classroom, the students went into the computer suite to read different articles posted by teachers and shared their ideas with each other. The teachers also moderated students' postings, with groups of students learning in the same room. While one teacher responded online, the other moved around the room to facilitate group discussions, and encourage better understanding of the topic. As noted in Chapter 3, effective use of *forum* helped nurture collaboration and relationship building, increased opportunities for students to receive feedback, and provided teachers with a unique window into student thinking. Using students' postings from the *forum*, teachers identified areas which needed re-teaching. These concepts were subsequently revisited to ensure that the students developed a thorough understanding before more teaching was done. This was a dramatic shift from how teachers interacted in a conventional classroom, to building a community of learning partnership.

The provision of some free choice learning was clearly appreciated by the students. There was evidence to suggest that students had started to take ownership of their learning by linking the objectives of the visit with their personal experiences, (e.g., reporting washing duck shooting equipment to ensure no weed seeds were brought home). The learning experience gained from 'what if scenarios' as well as learning as a community on the *forum*, helped students develop a better perspective of the topic they wished to explore. It appears that if the students are provided with information using multiple data sources, encouraged to collaborate via *forum* as well as engage in LEOS, they were then able to make informed choices on the topic they wished to research.

Identifying affordances of Moodle with both teachers and students helped integrate all three types of learning, formal, non-formal and informal in this phase. It could be said, however, that schools where this learning tool is used in classrooms, could have utilized *forum* directly. Induction to the different features of Moodle, with students and teachers, and ensuring teachers moderated the posts, maintained communication, promoted reflective thinking, and helped increase the quality of student work. It also became evident from interviews that exposure to learning as an e-community changed the way most students perceived the use of Moodle. There were, however, a few students who continued to rely on their teacher as they felt reassured they were doing the right thing. It appears that reliance on teachers was a way to escape fear of not doing well in examinations.

Sharing information became an important part of informal learning and the postings on *forum* suggested that the students developed a better understanding when learning as a digital community. It was also interesting to note that some students, who were usually quiet in the classroom, responded actively via *forum.* Communicating using the LMS thus helped provide autonomy for students who were usually silent in the classroom, as peers encouraged and supported one another. Additionally, students provided webpage addresses to show the sources of materials which were used to make postings. There was also evidence of the development of shared responsibility for learning amongst the students, and group leaders made sure all members contributed to the *forum* discussions.

Furthermore, the data indicated that preparation by the ISI staff on the day of the visit had a profound impact on the topics students chose to research. Between the RCT and Mr. Linc's team from *Island Ecological Reserve*, it was evident from students' interviews and reports, that members of RCT prepared a more engaging and meaningful presentation. The team provided written materials on *1080* and *Kauri Dieback*, both of which students found useful when completing their reports. In this phase of the inquiry, Mr. Linc did not present a 45 minutes lecture, but instead his team took students on a guided tour of the reserve, something much appreciated by students and teachers alike. These interactions which included considerable humor, helped students enjoy the experience as well as develop an appreciation of the effect of pest eradication on a large scale. These interactions resulted in a small cohort of students writing reports on *Pest Eradication*. Student academic performance showed a modest improvement from the previous year, with only five students being unsuccessful in this achievement standard (see Table 6.3). However, the teachers did not believe this failure was due to the new teaching approach.

Finally, while the teachers and students made extensive use of *forum* as a medium for collaborative learning, the functions of *wiki* remained unexplored. The reasons provided were that both students and teachers were keen to learn and use *forum* for collaboration, and so did not get time to learn about *wiki*. Therefore, the third phase of intervention placed emphasis on the use of *wiki* to help co-construct knowledge.

7.2.3 Third Phase of Intervention

The third phase of the intervention placed emphasis on integrating *wiki* with LEOS and classroom practice. This phase of the inquiry was based on the strand called

Planet Earth and Beyond. This involved the achievement standard AS90954, *Astronomical Cycles and Effect on Earth.* As reported in Chapter 3, affordances of *Web 2.0 Technologies*, in this case *forum* and *wiki* were seen as essential components of supporting students learning environment. Examination of postings on *forum*, in the second phase of intervention, showed evidence of reflective thinking, collaboration, and building of learning partnerships, where students and teachers supported each other and where there were more opportunities for students to receive feedback.

The third phase of intervention using *wiki* demonstrated shared ownership of knowledge. The findings indicated that the students felt included in all discussions. There were opportunities for group participation, which allowed for distributed cognition. Students reported that they felt valued and benefited from the support provided by both teachers and members of their group. The teachers as well as the Head of Faculty had reported earlier that the staff members were not pleased with students' performance in this achievement standard given the last two years, and so welcomed changes to their classroom practice, which might produce better learning outcomes. The notion of taking a multimodal approach, as well as integrating learning by engaging in LEOS was appreciated by both students and teachers. Students by this phase of the intervention were now familiar with the affordances of two features of Moodle, and were willing to continue using these because they could access information from home, received timely feedback from peers and teachers, and felt valued and supported when learning as a community.

The LMS was used to support a social constructivist epistemology of teaching and learning within Internet-based communities. The findings reported in Chapter 4, Section 4.3.1, indicated that Moodle provided an informal, flexible environment for learning communities; the notion being that not only the teacher, but also the students contribute to the overall educational experience. The integrated learning model was compared with the *Tree of Knowledge, Tane Mahuta* (see Chapter 4, Section 4.3).

The Integrated Learning Model: Tane Mahuta (Maōri name for *Lord of the Forest* - refer to Figure 4.1), was used to analogise between parts of the plant and their functions, and how these were similar to the various elements involved with integrating learning model. When considering the *Tree of Knowledge* analogy, the LMS (analog=*the roots*) helped provide the platform to support learning just like tree roots which help anchor and support the plant. As noted in Chapters 3 and 4, LMS helped in collaborative learning, similar to the way scientists use the Internet for sharing knowledge and expertise. The learning platform is then like the tree roots, because it helps in sharing information to support collaboration and knowledge building. The LMS can be used by teachers to notice students who are lagging behind, provide timely feedback, social support, make science accessible, and help promote autonomy in learning.

Furthermore, the teacher (analog=*the trunk*) played a pivotal role in the integrated learning model, by providing a link between the new media literacies (NML) (analog= *the soil*) and the learning outcomes (analog= *flowers & fruits*). However, in order to use IT as an integrated medium of instruction, teachers first had to up-skill themselves with LMS technical skills, and this research suggests that this requirement often reduces its use, or leads some teachers to abandon its use entirely as was the case in the first phase of the study. It appears that it may be teacher attitude which contributed to lack of student participation in the LMS, during the first phase of study. However, the uptake of this new approach to teaching and learning improved in the second and third phases of study. Teacher enthusiasm was complemented by active student participation in LMS. Teachers also played a multi-faceted role when engaging in integrated learning model. They helped prepare a learning culture where they created an interactive learning environment in the classroom, during LEOS as well as in LMS. Postings on Moodle helped identify student's prior knowledge, as well as gaps in their learning, which enabled adequate and timely feedback to support conceptual change necessary. These asynchronous interactions via *wiki* (analog=*minerals*) and *forum* (analog=water) are similar to processes which occur in tree trunk which help carry them from *the soil* to other parts of the plant in order to produce *flowers & fruits*.

The learning environment (analog=*the atmosphere*) in this phase of the intervention was both real and virtual, which helped support the development of conceptual understanding. Qualitative data on interactions indicated that students engaged in co-construction of knowledge when collaborating via *wiki*. As reported in Chapter 3, the intent of ICT was to support constructivist minded ideas about teaching and learning (see Table 2, Chapter 3). LMS consists of those experiences organised specifically to support formal educational achievement but accessed in informal conditions, in this case during LEOS and when collaborating via *wiki* and *forum* outside classroom hours. The themes which emerged from analysis of these findings indicated an increase in student motivation and self-autonomy. Just like abiotic and biotic factors are crucial in the growth and development of a plant, so are virtual (*wiki* and *forum*) and real (LEOS & classroom) learning environments (see Section 4.3.6), which helped integrate knowledge from different contexts and multimedia spaces to determine the type of learning taking place (see Chapter 3, Table 3.3).

As noted in Section 4.2.2, learning is seen as inextricably related to the social setting, which in this phase consisted of the classroom, ISI and virtual space via the LMS. Learning thus occurred by a process of social interchange where students made new meaning. Qualitative data from interviews, field notes and classroom observations, indicated non-formal and informal learning experiences complemented and enriched the school curriculum. Chapter 4 (Section 4.2.2), reported on three contexts which influenced learning at ISIs; the *personal context* (prior knowledge, interest, motivation, expectation and experience), the *sociocultural context* (influence of people), and the *physical context* (physical learning environment). Inferences from these findings with reference to *personal context*, suggested students took ownership of their learning by asking questions which were not part of the assessment, relating their findings to personal experiences, and developed conceptual learning as well as retained information for a longer period of time. Therefore often of the *sociocultural context*, which included the personality of ISI staff as well as the delivery of the program appeared to have a substantial impact on student engagement and interaction, as well as the choice of topic to research. The *physical context* was an important determinant again in student engagement.

Themes which emerged from the discussion of findings, suggested students were more engaged at ISIs which had targeted activities, presented in interactive ways, and included humour. It appears that the use of Moodle as a learning platform helped integrate formal, non-formal and informal learning, which substantially influenced students learning outcomes. On a similar note, surroundings of *Tane Mahuta*, by fungi (analog=*Mycorrhizae*), significantly influenced its growth. When plant roots are surrounded by Mycorrhizae, they develop a mutualistic relationship; the fungi have a higher absorptive capacity for water and mineral due to the comparatively large surface area, thus improving the plant's mineral absorption capabilities. But, it also draws carbohydrates from the tree roots for its survival. This symbiotic relationship helps promote healthy plant growth, in a similar way to the LMS integrated approach which included classroom learning and LEOS, fostered better learning outcomes.

Wiki and *forum* are new social software technologies, which are available modern classrooms and which are intended to support student learning by capitalizing on students' interests and familiarity with on-line communication. The affordances of these two features of Moodle helped students engage in informal learning, something which was absent in the Year 11 classrooms at *Rural High School*. *Forum* enabled students to network and collaborate on different issues, showing several authors. *Wiki*, on the other hand was used to co-construct knowledge, and several students co-authored the same document, developing a common understanding of the topic. The themes which emerged from analysis of these rich qualitative data from *wiki* and *forum* suggested that students demonstrated awareness and understanding of their own thought processes; hence, it seemed students engaged in metacognition. Students did not just recall answer, but used data from the Internet and ISI staff to make informed postings on *wiki* which demonstrated changes in their thought processes. As reported in Chapter 3 (see Section 3.4.2), engaging via LMS helped motivate students to take ownership and control with respect to pace and choice of content for learning. The use of analogy to describe *forum* (analog=*water*) and *wiki* (analog=*minerals*), which are essential ingredients for plant growth is a useful way to represent affordances for collaborative learning provided by these two features. Water is a solvent which helps dissolve minerals to carry them around the plant. It is essential because minerals by themselves cannot move through plant cells and tissues. In the same way *forum* was used in the second and third phase of study to develop familiarity with the tool to communicate. It appears that collaboration via *forum* was necessary to motivate and engage these students who were unfamiliar with the idea of learning via Moodle. *Wiki* (analog=*minerals*) are essential elements needed to build biochemical products, such as carbohydrates and protein in plants. Without minerals, the plant will not be able to survive with water only. In the same way, while *forum* helps in collaboration within an e-learning community, *wiki* enables these members to co-construct knowledge and subsequently develop a common and deeper understanding of the concept, enabling conceptual change.

Emerging technologies such as Moodle provided participation opportunities for students which is limited in traditional, teacher-centered classrooms (see Table 3.2, Chapter 3). As reported in Section 4.3.5, NML were used for three key purposes; it helped reach out to a teachers, students and resources, and to connect socially to share information and ideas as well as expand practices via multiple modalities which helped construct relationship and knowledge. In this inquiry, the affordances of Moodle helped with the processes of meaning-making. The qualitative data in the third phase of the intervention indicated that students interpreted information presented in different formats, namely, diagrams, graphs, texts and from LEOS. Synthesizing information from multiple formats and then making postings on *wiki* displayed intertextuality of information, an evidence of developing NML skills. Qualitative data from students' reports, postings from *wiki* and *forum*, as well as students' work-books, point to a deeper and comprehensive understanding of the concepts learnt in the achievement standard. Students provided evidence-based arguments; some made drawings to explain, rather than copy-pasting pictures from other sources. The synthesis of information using multimodalities, helped develop NML (analog=*the soil*). Here the soil has several microclimates which the plant uses to produce flowers and fruits. If the plant is able to use different materials from the several microclimates, it will then be able to process and survive climatic changes; had a similar challenge occurred. In the same way, the students were able to process information presented in multiple formats and from different sources, making intertextual links which helped improve the learning outcomes.

The learning outcomes (analog=*the flowers & fruits*) was the summative assessment; student's completed individual reports in two hours under examination conditions. These reports provided insight to students' interpretation of their findings, obtained from multiple sources namely resources on Moodle, classroom discussions, LEOS and from ISI staff members, and learning via e-community. It appears from assessment results, (see Tables 6.2, 6.3 & 6.4) that using an integrated learning model helped improve student learning outcomes for these achievement standards.

As reported earlier, the teachers played a multi-faceted role during the intervention part of the study. It must be noted that teacher enthusiasm and willingness to cooperate was one of the most important underlying factors which effected changes in curriculum delivery. These early adopters, who drew upon students ideas and liaised with ISI staff, provided targeted activities, which consequently brought about improvement in student performance across all three standards in the year of the inquiry and in particular for AS90954, *Demonstrate Understanding of the Effects of Astronomical Cycles on Planet Earth*.

7.2.4 *Section Summary*

In summary, the research question two adopted a three phase intervention study. The first phase which included better pre- and post-visit planning as well as some free choice learning, did not integrate digital support for curriculum delivery. Reasons for low integration stemmed from a lack of teacher preparedness to adopt innovative ideas, professional support, awareness on affordances of Moodle, and other digital devices available in the school. The second phase maintained all procedures from the first phase, but integrated *forum*, for group collaboration, building relationship, providing timely feedback and increasing autonomy to the silent ones. This phase involved the ICT Department, School Careers Advisor, and two groups of ISI staff. The third phase involved an integrated learning model, which fully integrated classroom practices with digital technologies, in particular, *wiki*, which displayed shared ownership of knowledge amoung students. The *Tree of Knowledge* was used as an analogy for the theoretical framework for this inquiry. The analogies was used to show how conditions needed for healthy plant growth are similar to having conducive learning environments (virtual & real) in order to develop conceptual understanding when engaging in LEOS. In the next Section, the findings are compared and contrasted with the literature presented in Chapters 2 and 3.

7.3 Conclusions

7.3.1 Conclusions for Research Question One

Are New Zealand teachers' current practices in LEOS effective in producing the desired learning outcomes for developing scientific understanding as evaluated against the New Zealand Curriculum achievement objectives?

Research reported in the literature suggests that learning at ISIs is influenced by a number of factors, namely teacher preparation, choice of ISI and the nature of ISI staff, as well as inclusion of free choice learning. Researchers note that the visits to ISIs such as zoos and museums if not planned properly by teachers, that is, employing proper teaching pedagogies and setting specific learning outcomes, results in missed opportunities for learning (Kisiel, 2003; De Witt, 2007; Tofield et al., 2003; Tunnicliffe et al., 1997). Findings from the first part of this study which relate to research question one, indicated that lack of planning by teachers resulted in little evidence of learning outcomes during LEOS. This was mostly because the subject teachers were not involved in planning this trip and equally did not intend to assess any learning outcomes as the visit was conducted on the second last day of the year. These findings are similar to work reported by Kisiel (2003) and De Witt (2007), who observe that not all interactions at the ISI result in better learning outcomes unless teachers adequately prepare for such visits. The literature states that LEOS results in limited learning outcomes, when teachers are more concerned about student behaviour, want them to only learn tasks which they have planned, keep to rigid timelines, and insist students simply complete worksheets (Griffin, 2004; Griffin & Symington, 1997; Kisiel, 2003). This parallels findings from the present study, which indicated that teachers were concerned about student behaviour and keeping to rigid timelines, so the students could board the buses at a specified time at the end of the day. There was no evidence for students learning at the ISI, and/or completing worksheets to record their discussions.

It seems that choice of the ISIs should be such that they are emotionally stimulating, and have motivated ISI staff who share their experiences enthusiastically, and encourage interaction with students (Tofield et al., 2003). For younger students, enthusiastic ISI staff in particular who explain things well, and take an active interest in students, are reported to have a positive impact on students' memory and attitude towards learning science (Jarvis & Pell, 2005; Tunnicliffe, Lucas & Osborne, 1997). The findings from the first part of this inquiry show that the students had visited the same ISI last year, and the ISI staff lacked humor and any social engagement.

There are numerous studies in the literature which report that while LEOS helps give meaning to abstract science ideas learnt in the classroom (Aubusson et al., 2012; Gardner, 1991; Orion & Hofstein, 1994), there is a need for proper planning if we are to maximise learning opportunities. That is, preparing a learning environment where informal learning can be self-paced and self-directed (Griffin & Symington, 1997). As noted by Falk and Dierking (2000), LEOS planned properly with some degree of choice helps improve learning outcomes. This is consistent with findings of Rennie and McClafferty (1995, 1996) on inclusion of some freedom of choice in learning. Informal learning at an ISI should then include free choice learning, which acts as a mediation tool and helps scaffold students learning (Jarvis & Pell, 2005). This helps students to collaborate in groups, and ask personalised questions which are not formally assessed. According to Bamberger and Tal (2007) and, Jarvis and Pell (2005), this enables growth of individual identities (see also Griffin, 2007). However, Tofield et al. (2003), argue that the constituents of the environment are free choice in nature, activities that remain highly teacher-centred, reduce student choices about their learning, thus affecting the learning outcomes. This part of the inquiry revealed complete lack of any inclusion of free choice learning, which resulted in students' disengagement from the task. Equally as no assessments were carried out, there was no way to measure if any learning had taken place. In summary, findings from this part of the inquiry support literature recommendations that pre- and post-visit preparation by teachers helps improve the learning outcomes during LEOS. Section 7.3.2 which follows discusses findings and conclusions drawn for research questions two.

7.3.2 Conclusions for Research Question Two

Is an intervention based on learning support provided by digital means effective in producing desired learning outcomes when evaluated against the New Zealand Curriculum achievement objectives?

Research question two adopted the implementation of a three phase intervention. The inquiry was conducted within a constructivist-interpretive paradigm that utilised a research methodology which ascribed to a contextual and social constructivist belief system. Development of the conceptual theme for the inquiry was based on Vygotsky's (1962) work, which emphasised the role of language and social environment in learning. The implementation of the social aspect of learning is supported by Tobin and Tippins (1993), von Glasersfeld, (1993, 1995) and Duit and Treagust (1998), who reported that knowledge that is constructed in a personal way makes sense to an individual. Social constructivists note that in order to increase the likelihood of students' individual talents, there is a need to provide opportunities as well as assorted resources, for social interaction and subsequently social construction of common knowledge and understanding, including scientific concepts (Solomon, 1994; von Glasersfeld, 1993; Wheatley, 1991).

This phase of the inquiry resulted in identifying, an integrated learning model, or blended learning model, which comprised of both real and virtual experiences. The real experiences were formal learning (Coll, Gilbert, Pilot & Streller, 2013; La Belle, 1982; Rauschenbach et al., 2004), which was institutionalised, teacher-centered, and assessment driven, and the non-formal learning occurred during LEOS. Here, learning was organized but occurred outside the school. The informal learning, which also included some free choice learning, took place both at the ISI, between students and between students and ISI staff, and in a digitally-supported environment, using features of Moodle such as *forum* and *wiki*. The conclusions made from the first phase of the intervention are discussed next.

The New Zealand Curriculum recommends that teachers create learning environments, where there is a learning partnership through learning conversations (MoE, 2007). This inquiry adopted these recommendations by engaging in LEOS and facilitating learning using digital technologies. A change in pedagogical approach was needed to help integrate three types of learning, formal, non-formal and informal, in order to enhance the learning outcomes in science during LEOS.

Findings from research question two indicated that there were a number of factors affecting the learning outcomes when engaging in LEOS. Tofield et al. (2003) and Tunnicliffe et al. (1997) claim, that better pre- and post-planning helps improve learning outcomes from visits to ISIs. However, in this phase of the intervention, examination of the teacher planner showed that the students had been exposed to greater range of instruction for the topic than had been in the past. This improvement in pre- and post-visit planning to the ISI, in this case, the *Show Home*, helped provide a social setting where students socially constructed knowledge.

The findings strongly supported Vygotsky's view of social constructivism where he emphasised the need for culture and social context for cognitive development. The students were keen to observe the structural features of the house, which made it energy efficient, and related these findings to the concepts learnt in the classroom. They also expressed a strong desire to engage in LEOS because this environment allowed them to learn in groups. The extra depth of explanation on heating efficiency between an old and new home is then a likely reflection of these learning experiences. These findings are similar to work by Biggs (1999), Falk and Dierking (2000), Goodrum (2007) and Preston and Rooy (2007), who reported that learning was enhanced in a social setting where students could actively participate and create new meaning.

An additional feature was that teachers made contact with ISI staff before the visit, which helped provide targeted activities when students visited the site. Interestingly, for some specific science concepts (e.g., conduction, convection & radiation), the students seemed to possess a good understanding of these terms. However, this may not have been due to the visit, but because the students had received prior instructions before the visit. But it could also be because the ISI staff were enthusiastic and encouraging, similar to the findings of Jarvis and Pell (2005) and Tunnicliffe, Lucas and Osborne (1997), who argue that an active interest in the activity by ISI staff has a positive impact on students' memory and attitude toward science.

The findings from improvement in pre- and post-visit preparation, along with other related studies (e.g., Biggs, 1999; Falk & Dierking, 2000; Goodrum, 2007; Preston & Rooy, 2007), thus point to the importance of creating a socially-mediated learning environment, which helps improve the learning outcomes in science. These settings could be 'real', such as classrooms, and at an ISI. It appears that LEOS, helps enrich students' learning experiences, which has a profound effect on the affective domain. The desire to build their own home, as well as some students seeking career pathways in the building industry, is consistent with the findings of Tal (2012) and Tal and Steiner (2006) who reported that ISIs provide students with opportunities for integration of scientific concepts, access to 'big science', can have a positive impact on long term memory (Farmer, Knapp & Benton, 2007; Gostev & Weiss, 2007; Whittington, 2006), and provide exposure to future careers (Hofstein & Rosenfeld, 1996).

The inclusion of some free choice learning as discussed above (see Section 7.3.1), also helped improve learning outcomes. There are several phrases used in the literature such as, 'some degree of choice' (Falk & Dierking, 2000; Rennie & McClafferty, 1995, 1996), 'limited choice' (Bamberger & Tal, 2005) and 'free choice learning' (Tal & Morag, 2007), all of which speak of varying degrees of learning driven by students' interests, rather than by their learning needs when visiting ISIs. Additionally, Rennie and McClafferty (1996), note that students' develop an increased level of enthusiasm when they are given the opportunity to discuss their findings within their groups and with experts (i.e., the ISI staff). These types of rich dialogues, where students actively participate and create new meaning, have a positive influence on student learning and attitude toward science. The findings of the present inquiry are consistent with those of other studies (e.g. Ellenbogen, Luke & Dierking, 2004; Fienberg & Leinhardt, 2002; Leinhardt, Crowley & Knutson, 2002; Rosenthal & Blankman-Hetrick, 2002) who report that students construct knowledge through collaboration. Equally, if an interesting context is provided, in this case, the *Show Home*, which intrinsically motivates the learner, students seek further information and become more persistent learners (Campbell & Tytler, 2007). This notion is supported by Koran and Baker (1979) and Lave and Wenger (1991), who claim that field trips provide an effective instructional experience to students, compared with conventional science classrooms. Affective variables, it is argued, influence student learning and helps bring about conceptual change which was evidenced from the assessment results of this achievement standard AS90943, *The Design Game: Keeping Your Home Warm*.

The findings of this inquiry are similar to those of other studies involving opportunities to take control of their learning in less formal environment, such as ISIs. For example, previous studies found that students preferred to socially construct knowledge (e.g., Griffin, 2004; Scott, 1998). In this work, student discussions at the ISI included in-depth explanations on heat transfer processes and heating efficiency. This is most likely due to the fact that such flexible learning environment encouraged more participation between students and the ISI staff. While such collaborations are feasible in a 'real' setting as mentioned above, Leuhmann and Frink (2012) as well as MacBride and Leuhmann (2008) observe that the same could be achieved in a 'virtual' setting, using a LMS, such as Moodle. Integration of classroom practice with ISI visit could then potentially be achieved by engaging in more social collaboration using the *forum* feature of Moodle. In this way, all three types of learning, formal, non-formal and informal are integrated using digital technologies. While this is possible, as seen in this inquiry, it again required preparation by teachers to help engage the students in informal e-learning environment.

Hence, it appears that provisions for informal learning during LEOS were preferred by students in this inquiry, in contrast with assertion of Gerber et al. (2001) and Zandvliet (2012), who state that students use the Internet as a learning environment in both non-formal and informal learning settings. Nonetheless, the data suggested that both students and teachers did not use the digital platform for collaborative learning. In this phase, it seems that this was due to the fact that both teachers were skeptical about using this innovative approach in their classrooms. They believed that inclusion of e-learning in classroom practice is more suitable when discussing socio-scientific issues. There was then no development of NML in this phase of the inquiry, consistent with the findings of Waight and Abd-El-Khalick (2007), who noted that views and perceptions of teachers and students in relation to specific learning environments, moderate the effectiveness of any technology in meeting stated or expected learning outcomes. Likewise, Becker and Ravitz (2001), Sandholz and Reilly (2004) and Zandvliet (2006), report that teachers often feel frustrated when they are required to spend time on technical issues rather than instruction, sometimes abandoning its use entirely. There is thus considerable commonality between the literature and the findings from this phase of inquiry. The conclusions from the second phase of the intervention are discussed next.

The findings of this phase of the inquiry are consistent with those of other studies involving ICT to afford new forms of participation. Moodle, a LMS, used as a cognitive tool also has a positive effect on the affective domain. However, Cuban (2001), Linn (2003), Sandholz and Reilly (2004) and Zandvliet (2006) report that simply increasing the use of computers or such technologies at a school does not necessarily result in changes in instructional methods and/or improved learning. This notion is further supported by Cope, Kalantzis and Lankshear (2005), DeGennaro and Brown, (2009), who stress the importance of teachers role in using digital tools to meet different learner needs, in order to achieve the expected learning outcomes. In the present inquiry, there were a few students who struggled to take up learning asynchronously via *forum.* When students struggle to take up a new mode of learning, they continue to depend on their teacher for learning support, as was the case in the early phase of this inquiry. Gerber et al. (2001) and Green and Hannon (2007), argue that students should be encouraged to develop a sense of self-directedness, mentoring and modeling roles in digital spaces. Typically, according to these authors, students need to be grouped with those who can provide peer support and encouragement. Such students will also need more exposure to different sources of information, such as from ISI visits and multimedia spaces, in order to develop confidence to collaborate and share information from multiple sources via *forum*. There was merit in integrating all three types of learning via digital technologies, in particular, using the *forum* feature of Moodle. *Forum* postings allowed students to view their individual work, hence increasing digital participation.

There are research studies on affordances of blogging (in this case using *forum*) which state that its effective use promotes reflective thinking, nurtures collaboration and helps build relationships (Leuhmann & Frink, 2012; MacBride & Leuhmann, 2008). Digital spaces help students take ownership and control of their learning as asserted by Chandra and Fisher (2009), Ryoo and Linn (2012) and Van Rens, Pilot and Van de Schee (2010). The present work likewise found that even though students were not aware of the affordances of Moodle, their uptake was rapid, probably due to the fact that they were digital-natives. The findings suggested that students readily took opportunities to collaborate using digital spaces, which helped establish a learner-centered learning environment, and they were motivated to learn. While this is possible, it requires teachers to provide students with these learning opportunities.

There are numerous studies which discuss teacher's role in designing lessons, which afford self-direction and autonomy (Lewin, 2004; Scanlon, Jones & Waycott, 2005; Willett, 2007; Zandvliet, 2012). A key outcome of this phase of the inquiry is similar to recommendations made by Osborne and Hennessy (2003) who note that effective use of ICT can be achieved when teachers structure activities which allow student choice, responsibility, and opportunity for active learning. Furthermore, work by Leuhmann (2008), Leuhmann and Frink (2012) and McBride and Leuhmann (2008) indicated that the resulting benefit of classroom blogging, in this case *forum* collaboration, depends on the lived practices of how students take up the design (or do not) and how teachers respond to student participation. While Kennedy et al. (2007, p. 522) reported that the "net-generation are not big users of *Web 2.0 Technologies*" findings of the present work are different, perhaps because the teachers actively moderated *forum* postings as well as student group leaders helped provide peer-mentoring and support. Teacher planning and peer mentoring, both generated spontaneous discussions where students started to share their lived experiences, which strongly suggested the development of self-directed learning. In this inquiry, examination of postings made on *forum* suggested that while there was a much shorter feedback cycle between works performed by students and guidance from the teacher, there was also some degree of development in the use of NML. Also, of importance here, is the impact of collaboration via *forum* at *Rural High Schools'* learning context. This is because the students expressed great enthusiasm towards learning to collaborate digitally as this was the first time they were provided with this opportunity. They recalled and shared their personal experiences to explain the activities they were asked to solve. Students here, worked as an e-learning community, encouraging and sharing ownership of learning, which helped increase students dependence and participation, similar to work done by Davies (2006) and Leuhmann and Frink (2012).

Griffin and Symington (1997), observe that when teachers provided opportunities for students to take ownership of what and how they are learning, it helped improve students' attitude towards learning science. This was evidenced in this phase of the inquiry where students informed their School Career Advisor of their interest in taking up volunteer jobs during school holidays at this ISI. It should also be noted that being an Enviroschool, (see Chapter 5) students of *Rural High School* are highly conscious of environmental changes and their consequences on biodiversity, which could have contributed to the idea of helping as a volunteer worker at *Island Ecological Reserve*. Next, conclusions from the third phase of intervention are discussed.

There are no reports in the literature describing that the use of NML in combination with pre- and post-visit activities helped improve learning outcomes when engaging in LEOS. There is however support for such an approval by authors such as Anderson (2002), Coiro, Knobel, Lankshear and Leu (2008) to move away from traditional classroom learning and engage via *Web 2.0 Technologies*, which they claim provides affordances to enhance teacher and learner participation.

The data regarding the third/final phase of the inquiry, suggested that learning outcomes are enhanced by integrating digital technologies in with pre- and post-visit activities when engaging in LEOS. The use of the LMS, Moodle, allowed non-linear, asynchronous nature of web-based learning, where students shared ownership of knowledge; a dramatic shift from *Web 1.0* technologies where knowledge was held within an individual. These findings are consistent with work by Lankshear and Knobel (2006, 2008), Leander (2007) and Leuhmann and Frink (2012) who advocate a move towards using digital multimedia rather than just textual spaces, where students can interact with one another in knowledge production.

As noted in Chapter 1, the New Zealand Curriculum encourages schools to draw upon non-traditional resources in order to help improve students learning and understanding in science. The research literature suggests that in order to engage students, there is a need to create inquiry classrooms which encompasses different values and expectations. To establish a new learning environment, this inquiry used LEOS to contextualise learning and *wiki* to increase both student and teacher participation. The findings are similar to work reported by Brown and Campione (1994), Crawford, Krajcik, and Marx (1999), and Duschl (1990) who supported the need for new tools, teaching approaches, and student expectations in creating a different classroom culture which subsequently may translate into improved learning outcomes.

Furthermore, this phase of the inquiry evidenced widespread support from both teachers and students about participation in LEOS, and collaboration using *Web 2.0 Technologies*. The teachers were keen to diversify their teaching approaches in order to improve students' achievement rates for this achievement standard which was not satisfactory in the last two years. The students were motivated about visiting an ISI, the *Observatory*, getting opportunities for free choice learning, and being able to collaborate digitally within groups, before and after the visit. That is, they were aware of their purpose for engagement during LEOS, accessed multimodal resources, and shared their findings via *wiki*. The students willingly took up non-linear, asynchronous learning because they had been inducted during the second phase of this study and so had some exposure to this approach. These finding take into consideration some concerns shared by Gee (2003, 2004) on factors which may inhibit the affordances of digital technologies getting translated into classrooms. However, the results are consistent with those of Annetta, Murray, Laird, Bohr and Park, (2008) and Leander (2007) who state that teacher attitude and belief, promotes social affordances, allowing students to assume new roles and providing autonomy in the co-construction of knowledge.

A key outcome of this part of the inquiry is consistent with those of other studies involving the multimodality features of *Web 2.0 Technologies*, and using them in productive ways. It offers a unique platform along with a number of features which can be used in tele-mentoring (O'Neill, Wagner & Gomez, 1996); in this case by both teachers as well as peers. Information in text and graphical formats reside in the virtual space, which students' access. These resources can be accessed by students to create their own texts and make postings on the *wiki* site either supporting or adding a different view point. This act of multi-mediating, that is making intertexual links helps students to map information by drawing inferences from multiple sources and recontexualising them to make meaning, which is shared by the groups (Gernsbacher, 1990; Hayes-Roth & Thorndyke, 1979). Doneman (1997) and Lankshear and Knobel

(2003) state that it is not the final product which students write, but the *process* adopted in producing it that is important. There is then considerable commonality between the present data and with the findings of Gernsbacher (1990), Hayes-Roth and Thorndyke (1977, 1979) who observe that integration of information is a cognitive process, where intertextuality of information enables high order thinking.

While majority of the studies in the literature, caution that intertextual integration does not happen to the degree that we would like, the findings of this phase of study are different from those reported by Hartman (1995), Van Meter (2001), Van Meter and Garner (2005), Tabachneck-Schijf and Simon (1998) and Thesen (2001). This different finding could be due to the fact that the present study involved students who expressed widespread appreciation for having opportunities to help co-construct knowledge within their group using multiple sources. Another feature which enabled intertextual integration was the use of mixed ability groups where students shared their interpretations using multimodal resources. It is important to note that the need to collect as much information on the '*print-friendly sheet*' of *wiki* in order to write the final assessment report was a catalyst for such active collaboration. Also, using blended classes as compared to traditional ones seemed to have a positive influence on students' attitude. They felt supported and reassured, which helped them to remain focussed and increased online participation. This was somewhat different to the findings reported by Fjermested, Hiltz and Zhang (2005), who reported mixed results when students only collaborated online. The data from this phase of inquiry revealed that a blended learning environment fostered better learning outcomes over online participation only. This was due to the fact that students had the opportunity to discuss ideas both in their classroom as well as online. This helped students to gain better clarity on concepts they were studying and they felt supported by both teachers and other students. In *forum*, the students debated and discussed their ideas. In contrast, following on from this, in *wiki* the students engaged in co-construction of knowledge, moderated by their teachers, who acted as facilitators, and thereby engaging in meaning-making. This meaning-making related science learning to the students own lives.

A substantial improvement in the quality of reports and pass rate for the achievement standard, AS 90954, *Astronomical Cycle and its Effects on Planet Earth*, suggested that students were able to interpret information presented in graphical and text formats, using multimodal resources, which led to deeper understanding of the topic. Focus groups interviews suggested that sharing of information on *wiki* by group members helped students who could not visit the ISI, to succeed in this topic. Therefore, mixed abilities grouping supported by teachers online could be seen as an important factor, which led to this outcome even though these students did not engage in LEOS. The present data were similar to findings reported by Brenner and Andrew (2006), who noted the importance of student grouping, and working with students on an on-going basis when engaging in online learning, helped improve learning outcomes.

However, work by Sproull and Kiesler (1986) indicated that if teachers fail to provide timely feedback, clarifying and/or correcting students work, in these types of asynchronous learning spaces, then there is a possibility of students developing misunderstandings. In this phase, the teachers were early adopters, who actively engaged in this inquiry by preparing for LEOS which included some free choice learning and moderated student's postings on *wiki* in a timely manner. This balance of teaching and learning reduced the transactional distance and increased social presence. The social networks within student groups and teachers helped foster and maintain knowledge flow.

The present work clearly identifies with those findings from the literature (e.g., Baskin & Anderson, 2008; Kleiner, 2002; Siemens, 2005) where interdependence and effective knowledge-sharing enabled students to develop personal understanding of the concepts under study. A marked improvement in this achievement standard AS90954, *Demonstrate Understanding of the Effects of Astronomical Cycles on Planet Earth*, during the year of inquiry as compared to the last two years suggested that an integrated learning model which received both student and teacher participation helped enhance the learning outcomes in science when engaging in LEOS.

In summary, there are three conclusions drawn from this inquiry.

- Firstly, by adequately preparing for both pre- and post-visit activities, identifying the particular type of ISI to be visited, having enthusiastic ISI staff as well as including some free choice, results in a substantial improvement in students' academic performance.

- Secondly, by integrating classroom practices and LEOS using the digital technology, *forum*, there was evidence of some development of NML, where students socially constructed knowledge which they accessed from multimedia spaces.
- Thirdly, by integrating all three types of learning using *wiki*, enabled accessibility, connectivity and multimodality amoung students, resulting in a significant increase in NML, evidenced by the improvement in students' performance outcome in the achievement standard (AS90954).

There are few studies reported in the research literature which measure the impact of LMS, like Moodle, a *Web 2.0 Technologies*, on student learning outcomes (Coates et al., 2005; DeNeui & Dodge, 2006). This inquiry, however, effectively integrated the three key features for teaching and learning via LMS, which are social presence, transactional distance, and social affordances, which were based on constructivist teaching principles, helped motivate students, and linked their findings to the real world. It must be noted, however, that these outcomes are strongly dependent on the crucial roles played by both the teachers and the students. Section 7.4 which follows discusses the limitations of this inquiry.

7.4 Limitations of the Inquiry

Considerable effort has been made to ensure the trustworthiness of this inquiry; the details of which are described in Section 4.7. Nonetheless, as in any inquiry some limitations are present and these are detailed here. The sampling for this inquiry was purposeful and comprised an even gender balance and spread of academic abilities. However, the demographics were such that it was dominated by New Zealand European students. Hence, the sample is not necessarily representative of the NCEA Level 1 (15 years old) student population in New Zealand secondary schools.
Likewise, the educational context was a private, religious, wealthy (Decile-10) rural,

secondary school in New Zealand. The teachers employed were highly qualified and experienced in their curriculum areas. The facilities and resources available at this school are at least different from those present at most other New Zealand secondary schools. Hence the context, teacher qualifications, and student family background is not necessarily representative of other New Zealand secondary schools.

The semi-structured interview protocol described in Chapter 4 (see Section 4.5.4) imposed some restrictions on the scope of the inquiry which may have resulted in both teachers and students' not having the opportunity to express their views fully. Similarly, the protocol meant that the interviews were comparatively lengthy and this may have restricted the interviewer's ability to probe understanding (e.g., clarifying use of terminology), particularly late in the interview. In addition, it is possible that the length of the interviews meant that some students' later responses were influenced by those who spoke before them.

Additionally, this inquiry employed only three Level 1 science achievement standards, all of which were assessed internally. It is possible that other standards in science and those across the curriculum at the same level may not produce a similar outcome. There are also differences in the ways in which the internal standards are administered at the different schools around New Zealand. Hence, the performance outcomes using these three achievement standards are not necessarily representative of other Level 1 science standards taught and assessed at this level in New Zealand schools.

Transferability is the constructivist equivalent to external validity or generalisability, which Merriam (1988) describes as "the extent to which the findings of one study can be applied to other situations" (p. 173). Generalisability is a common concern in qualitative inquiry because the onus is shifted from the inquirer to receiver (Guba & Lincoln, 1989). Whilst it is not appropriate to generalise because of the interpretive nature of this research, there are five clear implications which teachers need to practice. The first implication concerns using constructivism as a referent to teaching, which demanded a change in the way teachers prepared for LEOS. The New Zealand Curriculum places a strong emphasis on contextualising learning by taking students on field trips. Secondly, there is need to integrate LEOS with classroom teaching and visit ISIs while the topic was covered. Thirdly, there is a need to change the way schools liaised with ISI staff in order to prepare for more targeted activities. Fourthly, education on affordances on NML could be met with resistance by some teachers, as was the case in this study, and so there is a need for professional development in this area. Teachers need to become aware of their role when facilitating learning using digital technologies. Finally, both pre-service and in-service teachers may face procedural and financial challenges with inclusion of informal settings with science education programmes, but there is merit in doing this.

Finally, whilst NML could have been used for three key purposes such as accessibility, connectivity, and multiple modalities, the early phase of the inquiry saw limited use of the features of Moodle, because both staff and students were unfamiliar with the affordances of this LMS. Section 7.5 which follows discusses the implications of the inquiry for teaching and learning.

7.5 Implications of the Inquiry for Teaching and Learning

Tofield et al. (2003) suggested that a key finding of science education research is that pre- and post-visit preparation is essential when engaging in LEOS in order to improve the learning outcomes. It is equally important that during pre-visit preparation, teachers include strong curriculum links with classroom practices in their planning. The findings of this inquiry indicate that for the teachers at this school at least, such a dramatic change in role can be accomplished.

Tobin (1993) explained that constructivism, as a reflective tool, empowers teachers and enables them to fashion learning activities to the circumstances in which they find themselves. Therefore, it is important to consider including free choice learning during pre-visit preparation. Students develop an increased level of enthusiasm when they have opportunities to learn in groups and take ownership of their learning in an informal learning environment (Rennie & McClafferty, 1996). Where possible, science achievement standards should be integrated with LEOS as suggested in the

New Zealand Curriculum. These non-formal learning experiences should be conducted concurrent to the topic being taught and not done at the end of the year. Such a suggestion has been the cornerstone of a constructivist-based view of teaching- but how feasible such a recommendation would be at other secondary school around New Zealand, is debatable. Consequently, in order to teach from a constructivist-based viewpoint requires a shift in role of secondary teachers. That is teachers creating and facilitating a learning environment where students transform from being passive recipients of information to actively engaging in their learning process. Brown et al. (1989) pointed out that social interactions promote learning and social construction of knowledge. However, to achieve this during LEOS, teachers needed to liaise with ISI staff during pre-visit preparation to ensure the preparation of targeted and interactive activities, which are subsequently presented by enthusiastic staff. Such a shift is unlikely unless secondary school teachers feel a need to change and are involved in planning visits out-of-school.

At *Rural High School*, all achievement standards for the Level 1 science program were taught without engaging in LEOS. Moodle was used as a repository of resources and not as a pedagogical tool. Education drawing on the affordances provided by NML, when preparing for LEOS was not without resistance. Indeed, there was a noticeable lack of enthusiasm amongst some teachers. Perhaps the problem relates to this subject being unusual compared with other subjects that continue to be taught in a conventional manner. It comes as something of an unwelcome shock for some of the teachers in this inquiry to find that they have to become involved and actually prepare for LEOS to integrate learning using digital technologies. There then needs to be a school wide approach of integrating digital technologies with classroom practice so that both staff and students experience a blended learning environment across all curriculum areas.

It is important, that induction sessions are held with both teachers and students on how to use *forum* and *wiki* features of Moodle unless they are already familiar with it. It is equally important that both these features are discussed in depth, identifying the potential outcomes, and roles of both teachers and students to make these digital collaborations successful. The findings of this inquiry suggest that the initial introduction to collaborating using digital technologies should begin using *forum*. It was something welcomed by students, to find that they can become involved, and actually participated in their own learning. Once they have been introduced to digital collaboration, only then should the students be introduced to *wiki*.

Finally, Anderson et al. (2006) and Ferry (1995) observe that including informal science education with formal pre-service teacher education programmes can help improve attitude towards science teaching, which can also lead to higher levels of self-efficacy and self-confidence in teaching. However, Chesebrough (1994) and David and Matthews (1995) state that there is often the issue of procedural and financial challenges. The findings of this inquiry suggest that while the concept may be welcomed by in-service teachers, the rigid procedures of school for administering visits out-of-school may not be easy to change.

7.6 Suggestions for Future Research

The research findings reported in this thesis have raised some important issues for science teachers, at primary, secondary, and tertiary levels. Herein are reported some suggestions for future work, based on the findings of this inquiry.

First, if it is considered important to actively participate and create new meaning by engaging in LEOS, then an inquiry investigating the use of this new integrated pedagogical approach needs to be carried out for other science topics, using different ISI settings and at different educational levels. Primary school students could be used to measure how this innovative approach affects their attitude towards learning science. For tertiary students, the application of a teaching intervention based on a constructivist view of learning of a concept such as carbon dating would be of interest. The intervention could consist of a more innovative classroom practice where students engage in collaboration using *forum* and/or *wiki* before and after a visit to the ISI. An example in New Zealand would be to visit the national research centre such as Geological and Nuclear Science (GNS). Alternatively, instruction could comprise teaching using conventional methods; an inquiry investigating if this resulted in a better understanding of the concept of carbon dating would be of interest.

Second, this inquiry reported on the use of New Media Literacies to transform learning. *Web 2.0 Technologies* generally support the notion of constructivist-based learning (Downes, 2005) providing affordances via Moodle, which allows for knowledge building collaboratively. This approach helps to bring about high-order thinking (i.e., relational and formal understanding), encourages students to reason, and to think about and manage their own thinking (i.e., develop metacognition). With the availability of a multitude of electronic devices to access information on the Internet, these activities necessitate the development of transferable skills which in essence are the skills needed to adapt and apply the knowledge and skills to changing situations (Murray-Rust, Rzepa, Tyrrell & Zhang, 2004; Sasson & Dori, 2012). It would be interesting to investigate the implementation of an intervention where much greater use was made of such digital collaborations when engaging in LEOS.

Third, an inquiry comparing the impact of NML on learning outcomes in science during LEOS between rural and urban schools could be considered.

Fourth, the present inquiry involved only New Zealand European students and it would be interesting to extend this work by conducting a more systematic inquiry exploring the use of such integrated learning model in a multicultural learning environment that included indigenous (Maōri) students.

Fifth, a further area of future research would be how to maximise learning by teacher pre- and in-service development programmes. How might we guide pre- and in-service teachers to design LEOS experience which can maximise learning outcomes.

Finally, while much has been written about the potential of social software applications such as *wiki* and *forum* to encourage non-linear thinking in students, it would be of importance to conduct empirical studies on other multimodality features of *Web 2.0 Technologies*.

7.7 Chapter Summary

This chapter provided conclusions made from the findings for both research questions. The findings from research question one showed that initially *Rural High School* did not achieve any measurable learning outcomes when engaging in LEOS. It was basically a Science Faculty calendar event, which was a seen as reward by Year 10 students every year. For research question two, a three phase intervention resulted in a progressive change in the way LEOS was perceived, and prepared for, by both teachers and students. The Learning Management System was used as a pedagogical space by both staff and students, which helped transform learning. There was a shift from only using textual information to maximising the affordances provided by NML. Integration of classroom teaching and LEOS, with digital technologies, helped improve students' learning outcomes across all three different Level 1 science achievement standards.

The Chapter also discussed the limitations of this inquiry, which included the demographics of teachers and students sampled, context of study, interview technique, use of NML and achievement standard studied. It was also noted that because this is a case study the conclusions drawn are specifically relevant to the Year 11 science classrooms of *Rural High School*.

However, five implications drawn from this inquiry are; using constructivism as a referent for teaching, integrating LEOS with classroom practices, improving liaison with ISI staff, educating teachers on affordances of Moodle, especially on the importance of developing NML skills and including informal science education setting in science teacher programmes.

Finally, suggestions were made for future research. Due to the widespread use of Moodle as a portal across most schools in New Zealand, this informal, flexible learning environment should be explored with primary students to find out if it could influence their attitude towards learning science. Moodle includes a social constructivist approach to education, emphasizing that students (and not just teachers) contribute to the educational experience. Therefore, there is a need to use an integrated learning model with students' at all three levels, primary, secondary and tertiary, as well as in other curriculum areas. Also, there is scope in using this integrated learning model in a multicultural learning environment. Finally, there is also a need to explore other multimodality features of *Web 2.0* Technologies.

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APPENDIX A

Moodle Tool Guide for Teachers

Moodle Tool Guide for Teachers

What you want to use (technology) ↓ — What you want to achieve (pedagogy) →

	Ease of use How easy can this be set up by you?	**Information Transfer** Is it a tool for disseminating information from you to your students?	**Assess learning** Will this tool allow you to assess your students' learning?	**Communication & interaction** Can it be used for communication & interaction among participants (you & your students)?	**Co-create content** Can you & your students collaborate & create content together?	**Bloom's** Allows what thinking order? •Remember •Understand •Apply •Analyse •Evaluate •Create
Add Resource Upload a file (Word Document/ PowerPoint)	Easy, like an email attachment. But can your doc stand on its own?	Yes. Only teachers can upload files to course site. So definitely a push-tool.	Maybe. Use to give task. Collect student files through Forum or Assignment.	No. It's a distribution tool. No option for interaction or communication.	Maybe. Use to give task. Collect student files through Forum or Assignment.	None. This is not a learning activity, but information transfer.
Add Resource Link to a web page	Easy, find the web address (aka url – the bit that starts with http://), copy it, paste it.	Very easy way of leading students to information. Can link directly to database articles.	Not directly. Option is to link to external student e-portfolios or blogs.	Maybe. Link to external tools eg Google Calendar, groups, blogs or wikis.	Maybe. You can link to external collaborative sites e.g. Google Docs, wikis or blogs.	6/6 Can do all of the above, depending on where you link to.
News Forum Use to send out course announcements	Easy. It's a standard forum , already set up in your course.	Yes. Include course updates, encouragement, timely links, etc.	No. The News Forum is limited. Students cannot post new topics.	You can start new topics. Students respond. Great for establishing course rhythm.	Limited because students cannot start new topics. Tip: Set up another Forum.	2/6 Not strictly learning activity. Test readiness for next class? R & U
Discussion Forum Use for many types of learning activities *	Easy. Forum has usable default settings. A name & description is enough.	Share resources as links or files. High message volume? Risk of losing info.	Forum is versatile & allows this, e.g. design a formative assessment activity.	Yes. Students communicate with you & peers. Interact as a class or in groups.	Yes. Students can collaborate & explore topics, discuss them & write together.	5/6 Understand, Apply, Analyse, Evaluate, Create
Wiki Use for many types of learning activities	Tricky. Decide on individual & group settings. Has some quirks. Get some training.	Yes. Use as information site. Allow editing only by teachers or by any participant.	Wiki is versatile & allows this, e.g. design a formative assessment activity.	Not suited for discussions. Use in brainstorming, planning, collabo-rative writing,...	Yes. Students can collaborate & explore topics, discuss them & write together.	5/6 Understand, Apply, Analyse, Evaluate, Create
Glossary Use for learning activities that gather resources or present info	Default settings are good. Try to set it so the author's name is shown.	Use glossary to define terms or present info. Better yet, let the students add to it.	Glossary is versatile & allows this. But you need to design the right learning activity.	Not suited for discussions. Students can read other entries & comment or rate.	Only original author can edit an entry. Class can collect reviews, resources, etc	5/6 Understand, Apply, Analyse, Evaluate, Create
Quiz Use to assess learning, formative or summative.	Tricky & takes time. Set up quiz, then questions. Consider your categories.	The quiz is aimed at assessment, not as distribution channel. Tip: use as self-test.	Quiz can be timed & secure. Has essay, mc, true/ false, matching, & other questions.	No. Tip: Use forums instead.	No. Tip: Use forums or wikis instead.	6/6 Can test all 6 but this requires you to be creative in your assessment.
Lesson Use for presenting branched info or testing	It can be tricky to set up, make sure you plan the lesson first. Worth the effort.	Great for presenting information in a branched, guided way.	Yes, allows grading. Use as branched quiz, scenario, case study, role play.	No this is an individual activity, not a group activity.	No this is an individual activity, not a group activity.	6/6 Can test all 6 but this requires you to be creative in your assessment.
Assignment Use to collect, assess & provide feedback on assignments	Easy. Choose from 4 types. Both online & offline assignments are possible.	No. The assignment tool is not a distribution channel.	Yes. Set due dates & maximum grades. Collect assignments and provide feedback.	No. Only allows very limited interaction between teacher & student.	No. Currently it does not allow group assignments. Use forum or wiki .	6/6 Indirectly. Depends on your assessment design.
Database Allow students to collect, share & search created artifacts	Tricky to set up. Know what you want before you build. Get some training.	Can be used for teacher to present info, but better to let the students add to it.	Database is versatile & allows this. But you need to design the right learning activity.	Not suited for discussions. Students can read other entries & comment or rate.	Students can share info & files in searchable way. Create joint collections.	5/6 Understand, Apply, Analyse, Evaluate, Create

Great fit

Can work w/ some learning design

Not best tool for the job

How to use this guide
Are you a teacher new to Moodle? Use this guide to pick the right tool for the job.
•Know which tool you want to use? Follow its row across to see its strengths & weaknesses.
•Know what you want to achieve? Pick a column and follow it to see which tool will help you do it.

***Be creative with Discussion Forums**
It doesn't always have to be an in-depth class discussion. Other activity ideas: class debate, team discussions, report weekly project findings, web quests, role play & feedback, gather resources & reviews, assessment support, Helpline, NZ's Got Talent (use the rating), rotated student-led discussions, weekly magazine,...

Need more Moodle help?
•Moodle community at www.moodle.org
•Download **Using Moodle** book (it's free!)
•@lasic's 2 Minute Moodles videos
•@moodleman blog: www.moodleman.com
•Go meet your friendly e-learning, flexible learning or educational technology team. Buy them a coffee!

Joyce Seitzinger (@catspyjamasnz / www.cats-pyjamas.net) - May 2010

www.eit.ac.nz EIT

APPENDIX B

AS90943: Design Game-Internal Assessment

Achievement Standard Science 1.4: **AS90943 V1**

Investigate implications of heat for everyday life

Resource Title: The Design Game: Keeping your home warm

Credits: 4

Achievement	Achievement with Merit	Achievement with Excellence
Investigate implications of heat for everyday life.	Investigate, in depth, implications of heat for everyday life.	Investigate, comprehensively, implications of heat for everyday life.

Student instructions

Introduction:

This assessment activity requires you to investigate the implications of heat in an everyday situation. It is based on designing the layout of a house and how best to keep it warm. You will write a report on your investigations and draw valid conclusions which are explained in terms of the science ideas of the topic.

Read all of the instructions before you begin.

Conditions:

This assessment activity is to be carried out in two parts – Part One: design and insulation and Part Two: implications for heat loss/retention. The task will be carried out in pairs for the design and insulation (Part One) and individually for the interpretation and implications for heat loss/retention (Part Two).

You will be given 12 hours to complete this investigation:

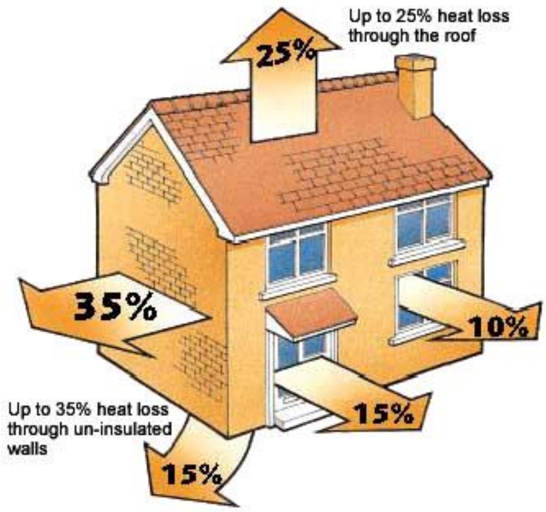
- Pre-planning, Planning, designing the house and processing/interpreting of secondary data: 8 periods. (Done in pairs)
- Writing the final report about the heat implications of your design: 4 periods. (Individual)

All plans, notes and work needs to handed back in to your teacher at the end of each period for re-issue to you.

You can do background research and/or gather additional information.

Setting the scene:

In a house heat escapes through the walls, roof, floor, windows and doors. By insulating a house and keeping the heat in for longer, we can halve the energy needed to heat it and halve the fuel bill. Below is a diagram of how much heat escapes from a house.



If we get the design and building materials of the house right, we can also use the Sun's energy to heat it.

The picture below shows a typical new house in New Zealand. The house is designed so it needs minimal energy to heat it. It has lots of insulation in the roof and walls as well as double glazing.

The house also uses the Sun's heat to warm it. The architects have designed the house with large windows that facing the North and small windows facing the South. This is called passive solar heating.

Part One: Designing the House (done in pairs)

You are going to imagine that you are an architect (someone who designs houses) and design your own home. You will produce a floor-plan of your home and then consider the heat implications of the home you have designed.

Before you produce your final floor-plan, you will need to read A, B, C and D below and provide answers for the questions in each section as part of your submitted report.

A The budget will allow you to design a **single level home**:

- 4 bedrooms,
- 2 bathrooms (1 can be an ensuite),
- office/study,
- an open plan kitchen/family/dining area,
- scullery (if you wish),
- separate lounge,
- double garage with attached laundry and plenty of access to outdoor living,
- an entrance lobby and hallways as needed.
- It can be any shape you choose.
- There are no trees or other features that will block sunlight. The site is flat.

Before you start marking out the rooms, you will need to answer questions 1-4.

1. Which room(s) will you spend the **least** amount of time in?
2. Which rooms should be the biggest and which the smallest and why?
3. Which rooms need to be kept especially warm?
4. How do I intend to heat the home in winter – fireplace, heat-pump, heaters etc. keeping in mind the cost to operate these.

B Using the Sun's heat to warm the home is vital. You will need to answer the questions 5-7.

5. Where does the sun (a) rise?
   (b) set?
   (c) shine for most of the day?

   It is important to decide on which side of the house you put each room e.g. if you are wanting to spend a lot of time in the lounge room, you might build it facing north with large windows with a veranda to provide shade in the height of summer. This means you will get a lot of sunlight in the lounge room: it is naturally warm, but cooled in summer by breezes under the veranda.
6. Which side might you put the rooms that are least used – service/utility rooms?
7. Which rooms are going to have large and/or small windows and why?

C When you decide where to put rooms, you need to consider the building code regulations. Some of these are:

- The bathroom/toilet entrances cannot be near the kitchen entrance.
- Each room must have an opening window (except walk in robes/closets).
- Access to certain rooms cannot be via bedrooms (e.g. to get to the kitchen you cannot go through the bedroom).

D You will need to consider the **size of the rooms** bearing in mind what furniture needs to go in each. Remember to leave space for opening of doors and that large rooms with high vaulted ceilings are more expensive to heat/keep warm.

E **Floor-plan layout:**

Use a piece of graph paper and use a scale of 2 cm by 2 cm to represent a square. This will equate to 1m by 1m in a real house on the site. You need to mark on it North, South, East and West.

Draw out the floor-plan of your house to scale. [one final plan per pair]

Suggest you do a mock-up before you do the actual plan to be submitted.
You will both need a plan as part of your write-up.

Remember to: Name the rooms
Mark any doors in **green** (both internal and external)
Mark windows in **blue**
Show the positions of any fireplaces, heaters or heat-pumps in **red**.

F **Gather secondary data**

In your pairs, collect relevant information on insulation and building materials from a range of sources. You are advised to use the planning template, Resource 1, (a blank template is accessible on the student share drive under Y11 → Science → 1.4 Heat Internal). Collect enough information to allow you to discuss the links between heat, home insulation and scientific theory when you do your individual write-up for Part Two. [Remember you both need a copy of the information!]

Checklist for submission of Part One:

- ☐ A: questions 1-4 answered.
- ☐ B: questions 5-7 answered.
- ☐ Have considered C and D when designing house.
- ☐ E: Floor-plan of house drawn to scale on graph paper and rooms etc. marked as per instructions.
- ☐ F: Gathered secondary data/evidence about the best building/insulation materials to use.

Part Two: What to build the home out of and how to insulate
This section is to be done **individually**.

Now that you have designed your house, you need to decide what to build it out of and how to best insulate it. You will need to read G, H and I below and provide answers for the questions in each section.

G You will need to answer the questions 8-11.
8. What external cladding materials offer the best insulation?
9. What roof shape(s) are best at retaining heat?
10. How can heat be used from the roof space?
11. How do you plan to insulate the various parts of the house externally (wall, ceiling and floor cavities)?

H Internal insulation. You will need to answer the questions 12-14.
12. How will you reduce any heat loss through the floor?
13. How will you reduce any heat loss through windows?
14. How will you reduce heat loss to rooms/areas that don’t require heat retention (garage, laundry etc.)?

I Write a report that discusses the implications of heat loss and insulation of your home in everyday life by:

- describing the 3 main methods of how heat is lost from your home and why it should be prevented;
- giving a scientific description of why you designed the floor-plan of you your house the way you did;
- giving a scientific description of how the physical properties of the chosen building materials aid their ability to insulate (prevent heat loss);
- discussing how the insulation ability of each material you have chosen to use in your home maximises heat retention;
- how should the material be installed (thickness, placement etc.) and the impact that water or moisture might have on the materials ability to insulate.
- linking the data you have gathered (R values etc.) about the various building materials to scientific theory, for example, providing scientific reasons why one material was a more efficient insulator than the another;

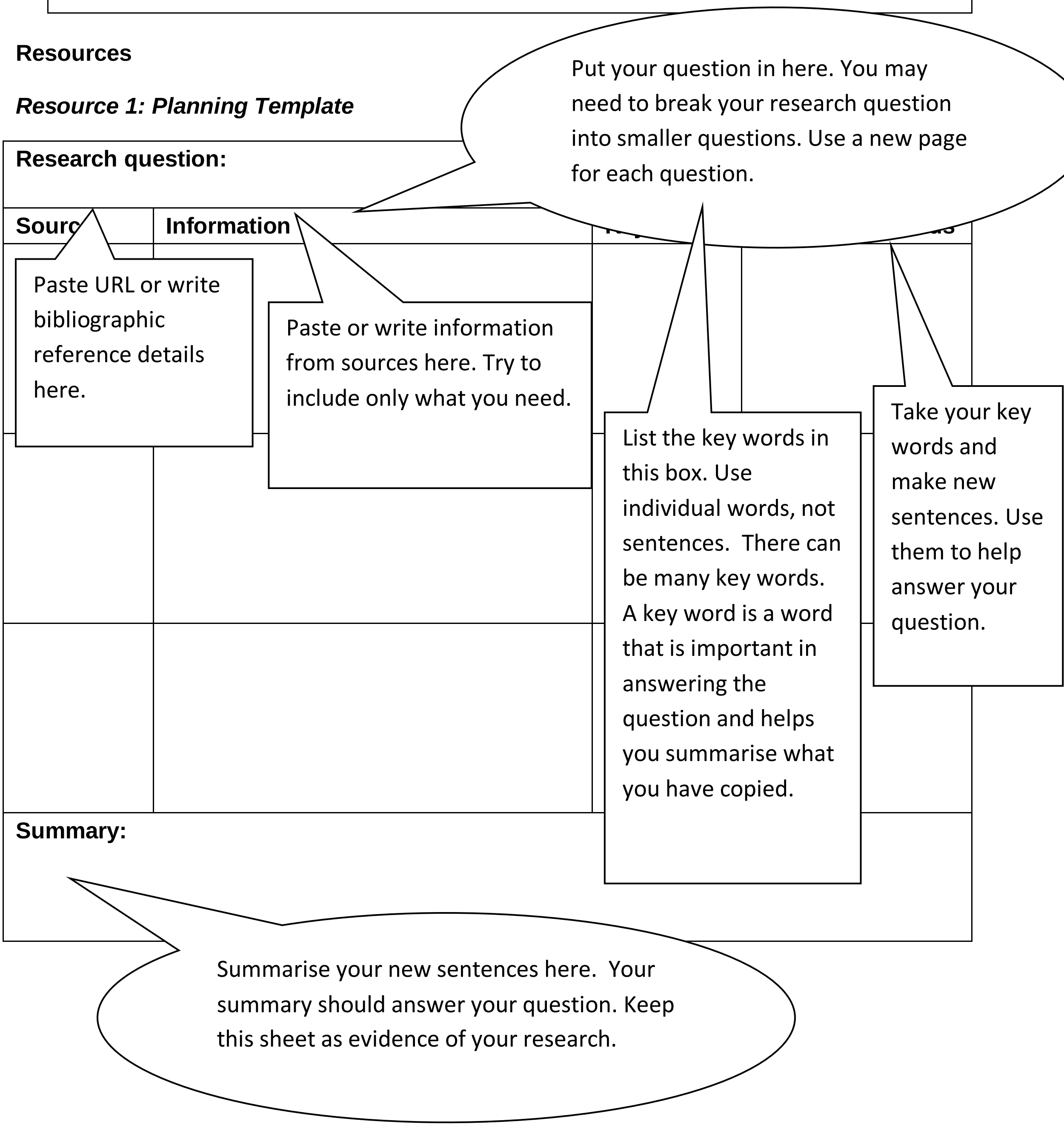
The quality of your discussion, scientific reasoning and how well you link this to the layout/design of your home will determine the overall grade. Use scientific statements, comparative data or statistics about building/insulating materials as appropriate in your report.

Checklist for Part Two:

- ☐ G: questions 8-11 answered.
- ☐ H: questions 12-14 answered.
- ☐ I: Report on heat loss and implications: how is heat lost, justify the house layout/materials you have chosen and why those materials are the best from a scientific viewpoint.

Resources

Resource 1: Planning Template



Assessment schedule: Science 90943 The Design Game: Keeping your home warm

Evidence/Judgements for Achievement	Evidence/Judgements for Achievement with Merit	Evidence/Judgements for Achievement with Excellence
Report includes the following: Part One: Questions 1-4 answered. Questions 5-7 answered.	Part One: Questions 1-4 answered. Question 7: why different sized windows explained.	Part One: Questions 1-4 answered with respect to why rooms of different sizes. As for Merit
Feasible floor-plan produced that meets the specifications of the design brief (has all the rooms asked for). N/S/E/W marked on plan.	Workable floor plan produced with all rooms asked for and takes into account building code given, size of rooms in proportion to use and scale correct on plan. Placement of any heating devices shown.	Fully functional floor-plan that takes into account, building code, room size, placement and orientation of rooms with respect to natural heating by sun angle/movement. As for merit.
Part Two: Questions 8-14 answered. I Report: Statement of which building/insulation materials are the best insulators, based on data gathered. Better insulation (lesser heat loss) explained with links to scientific theory about the physical properties of the materials used. General description of heat transfer mechanisms. Diagram or narrative description of why house was designed the way it was.	Part Two: Questions 8-14 answered. I Report: As for *Achieved*, plus gives reasons for the way science is involved.	Part Two: Questions 8-14 answered. I Report: As for *Merit*, plus report **<u>links</u>** reasons and implications in a way that the science involved is clearly explained. Connects science to house design/layout/site orientation.

Final grades will be decided using professional judgement based on a holistic examination of the evidence provided against the criteria in the Achievement Standard.

APPENDIX C

AS90926: Biological Issues-Internal Assessment

Achievement Standard Biology 1.2, AS90926: Report on a biological issue
Resource Title: Protecting Biodiversity
Credits: 3

Student instructions sheet

You will present a written report on an aspect of the issue of protecting biodiversity in New Zealand. You will have one week of class time to prepare. You will have two hours available to complete the written report. This will be done in class under test conditions.

Task 1 – Developing and refining a research question

Develop and refine possible questions, suitable for research, relating to the issue of protecting biodiversity in New Zealand.
Select one question on which to base your research. The question must relate to the biology of biodiversity in New Zealand and will help you to focus your research.
Submit your research question to your teacher before beginning your research. This is to be completed before ___________________.

An example of a topic is possums. An issue about possums is a question that people will have different answers to. For example, should 1080 be used to kill possums in the New Zealand bush? OR Is biocontrol of the New Zealand possum population viable? OR, Should DOC introduce a bounty for possum fur?

Task 2 – Collecting and processing information

Collect and process data and information relating to your research question from a range of sources. This will include:

1. Why protecting New Zealand's biodiversity is an issue.
2. The important biological ideas about biodiversity
3. Differing viewpoints that people have about biodiversity

Record all the sources you collected information from in a way that allows another person to find the same source. Also note any sources you do not use and explain why they were unsuitable.
Some sources you may choose to use are:

http://www.biosecurity.govt.nz/
http://biosecurity.org.nz/
http://www.newzealand.com/travel/getting-to-around-nz/getting-to-nz/customs-immigration/customs-immigration_home.cfm
http://www.doc.govt.nz/conservation/threats-and-impacts/biosecurity/
http://www.stuff.co.nz/business/farming/3508701/New-Zealands-biosecurity-questioned
http://www.stuff.co.nz/business/farming/4338776/Kiwifruit-disease-fears-spread
http://en.wikipedia.org/wiki/Biosecurity

You will have 1 week to collect and process information. You may do some research at home but if you do you must get an adult to verify you have completed your own work. You will be required to hand in all your research notes in the form of screen shots or photocopied pages from books or magazines with your final

report. Your teacher will show you the preferred format for constructing your research notes.

Task 3 – Reporting

Write a comprehensive report on an aspect of biodiversity in New Zealand in which you:

1. state your research question, which must be suitable for research and refined from the issue above;
2. discuss the biology relating to the question by making multiple links between relevant biological ideas;
3. identify two different points of view related to an aspect of protecting biodiversity in New Zealand giving reasons why the people, groups and/or organisations hold those viewpoints;
4. state your own position on the issue. Use information from your sources to explain why you hold that position;
5. make a recommendation for action in the future and explain your reasons for the recommendation;
6. evaluate at least three sources of information you have used explaining why they were suitable (or not) to collect information from. For example:
    - Is the information it contains useful?
    - Does it contain accurate biological information?
    - Is the information up-to-date (look for the date it was developed or last updated)?
    - Is the information fact or opinion?
    - Is the source biased to one particular point of view?
7. record the sources you used in a way that allows them to be found by another person. At least three sources must be used and referenced.

Assessment schedule: Biology 1.2

Evidence/Judgments for achievement		Evidence/Judgments for achievement with merit		Evidence/Judgments for achievement with excellence					
Given or agreed question or purpose refined		A suitable question or purpose refined from the issue provided *e.g. Why is burning fossil fuels an issue?*							
Collects and processes information from at least three sources.									
Describes biological ideas related to the question. (2+ Ideas)		Explains biological ideas related to the question. (2+ Ideas)		Makes multiple links involving the biological ideas that are related to the question or purpose. (2+ Ideas)					
		Identifies at least two different named points of view supported by evidence. (MAF/DOC/Fred the farmer from Tirau)							
Takes a position on the issue.		Takes and justifies a position on the issue. (link their position to their research)		Includes a recommendation for action with reasons why.					
Sources are recorded in a way that can be found by others.		Sources are recorded in a way that can be found by others.		Evaluates the reliability, relevance and validity of sources of information/data in respect to the question or purpose.					

For example: Report extract*.* *NZ glaciers are melting. The Tasman Glacier is the largest and it is melting adding millions of litres of water into the Waitaki River system. NASA scientists visited glaciers in 2008 to investigate the rate they are melting. Glaciers are melting at a faster and faster rate. They think that global warming is causing the faster melting. The carbon dioxide from home fires is adding to the atmosphere and causing the greenhouse effect. I think that it is a problem for NZ that the glaciers are melting quicker*	**For example: Report extract** *Wetlands are found throughout Southland - within indigenous forest, tussock lands and within developed pasture. Examples include high country string bogs of the Upper Waikai, lowland peat swamps of the Awarua Plains, the tarns and mines of the Te Anau Basin and the remnant domes of large peat swamps that once covered much of the Southland Plains. Many large wetlands have disappeared with the development of farm land. Draining, burning and clearing have removed most of these important habitats and unique ecosystems. Wetland habitats vary widely because of differences in soils, topography, climate, hydrology, water chemistry, and vegetation. For example the soils in peat bogs are dark brown and acidic due to the high content of partly decomposed organic matter. There are lots of benefits of wetlands. For example recreation, support fisheries, habitats, water flow regulation, nutrient filtering. In nutrient filtering the bacteria remove large amounts of nitrates from groundwater. They reduce flooding by holding water during high rainfall.*	**For example: See attached example of a report extract for evidence for Excellence**

Exemplar for Excellence - parts of a report

Why is burning fossil fuels an issue? Fossil fuels are coal, oil and gas and they are formed underground by the anaerobic decomposition of dead plant and animal remains. There are several reasons why burning fossils fuels is an issue. Firstly, these remains are a limited resource that takes millions of years to form but once they are used they are gone. The use of fossil fuels has nearly doubled every 20 years since 1900. The increasing demand is related to the use of fossil fuels for power generation, home fires, in vehicles and also in manufacturing to make plastics and many other products. Secondly, burning fossil fuels produces sulfur dioxide which forms 'acid rain'. Large coal burning power stations remove sulfur dioxide from the smokestack gases but home fires do not so are responsible for releasing large amounts of sulfur dioxide into the atmosphere. Thirdly burning any fossil fuel produces carbon dioxide, which contributes to the "greenhouse effect". The carbon dioxide dissolves in the water and the ocean acts as a buffer with little pH change. However the increasing amounts of carbon dioxide being released is too much so the pH of the oceans is slowing rising. This will have an effect on the organisms that may not be able to survive the increasing pH. Burning coal, the fossil fuel usually used in homes, produces more carbon dioxide than burning oil or gas. Lastly mining coal, oil and gas can be difficult and dangerous. When strip mining is used to mine coal it can destroy large areas of the landscape which have to be managed so that the area is returned to productive land as soon as possible. Environment Canterbury has developed new rules that prohibit the use of open fires and old woodburners within the Christchurch Clean Air Zone in the winter ie between 1 April and 30 September each year. The ban on use of open fires and woodburners older than 15 years is because home heating using wood and coal causes problem with air pollution in the winter months. Older burners are less efficient at burning the wood and coal so release more fine particulate emissions, called PM10. In the winter, on cold nights these particles cause thick choking brown smog over the city that is dangerous to people's health. On many winter nights the amount of PM10 particles in the Christchurch air is higher than Ministry for the Environment guidelines. This results in serious health problems for several thousand people. For example, more people develop cardiac or respiratory illnesses and there is an increase in the number of deaths as the result of these illnesses. Some people are also concerned that the smog has a bad effect on the public image of Christchurch city. In Christchurch there are hills close to the city which cause the formation of a layer of warmer air known as an inversion layer. This layer traps the smog below it. Normally the air is warmest at ground level and gradually gets colder the higher you go in the atmosphere. What happens in Christchurch is that at the end of a cold, calm winter's day, the temperature of the earth begins to drop after the sun goes down and the air next to it cools down. The nearby hills stop the air moving which stops the air from mixing and causes the formation of a warmer layer of air above the air that is cooling down. When the people lit fires the smoke containing the PM10 becomes trapped in the cooler air just above the houses and causes people to be exposed to this pollution.	This section of the report shows evidence of making **multiple links** in the relation to why burning fossil fuels is an issue i.e. is reporting comprehensively. This section of the report shows evidence of making significant links between the **biological ideas** and processes related to the issue i.e. is reporting comprehensively.

In 2004, Environment Canterbury carried out a telephone survey to find peoples' opinions on the air quality issue. The survey showed that 89% of people surveyed believed that Christchurch did have a serious pollution problem. The majority of people (73%) said that the air quality of Christchurch was a health issue because many of them knew friends or family members affected by the pollution.	First point of view given but not well supported with evidence from research.
Editorial in the Timaru Herald expressed concern that Environment Minister Nick Smith has announced a review of NZ air quality standards that were due to be implemented in 2013. While it is believed that a review may make implementation timelines more reasonable there is also the possibility that we "take our collective eye off the ball" in respect to improving air quality as progress is important to ensure better health for New Zealand communities. The concern that one high air pollution night in a year is allowed under the regulations whereas by mid June 2009 Timaru has already had four high air pollution nights and in 2008 37 high pollution nights occurred. It is thought that failure to comply with the standards, when implemented, would mean no air discharge consents could be issued and this would cause issues for industrial development in Timaru and could cost people future job opportunities. This is seen as unfair when the biggest cause of air pollution in our towns is home heating not industries.	Second point of view well supported by evidence therefore holistically the two points of view are acceptable for excellence.
I think the air quality in Canterbury is an important issue that people should be working hard to improve and recommend that Health Minister should continue with the 2013 implementation deadline. This is because of the health issues that PM10 pollution causes for people. For example PM10 pollution causes increased asthma, respiratory, and airways disease in children; damage to the lungs; increased admissions to hospital and deaths from lung and heart disease. When people breathe in PM10 pollution it damages the tissues all the way down the respiratory tract and into the lung. Because the particles are so small they can enter the bronchioles where they are attacked by macrophages. Sometimes the toxic pollution kills the macrophages and gets all the way into the aveoli of the lungs.	States own position making several linked points about health issues to explain why they hold position and recommends 2013 implementation.
I started my research using wikipedia and found it to be a very useful stating point from which I was able to improve my understanding of fossil fuels and it provided a range of possible sources of information. Other sites showed that the basic information in Wikipedia was scientifically correct and up-to-date, however I decided to compete most of my research using New Zealand sources.	This evaluation explains why the source was suitable to collect some information from.
Sources: http://www.ccc.govt.nz/quickanswers/community/cleanair/f4403.asp http://www.sciencelearn.org.nz/contexts/enviro_imprints/looking_closer/air_pollution_in_christchurch http://www.darvill.clara.net/altenerg/fossil.htm http://www.naturalnews.com/001398.html http://en.wikipedia.org/wiki/Fossil_fuels	At least3 sources used (i.e. a range) and recorded in a way that can be accessed by others

APPENDIX D
AS90954: Lunar-Our Moon-Internal Assessment

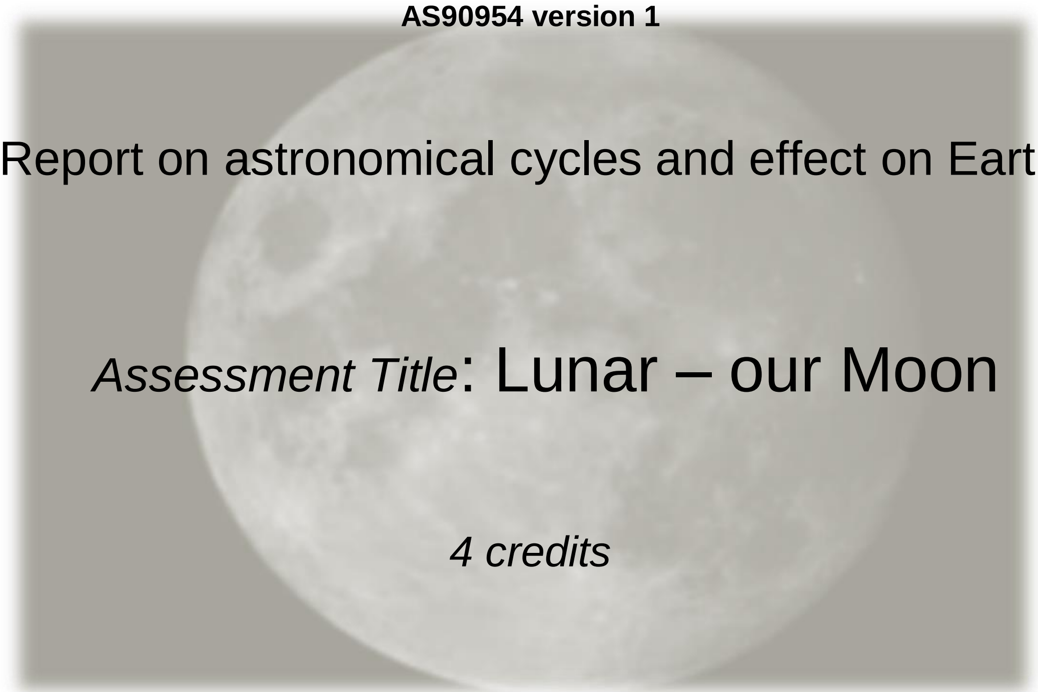
NCEA Internal Assessment Task

2014

Science 1.15

Level 1

AS90954 version 1



Report on astronomical cycles and effect on Earth

Assessment Title: Lunar – our Moon

4 credits

Conditions of Assessment	Maximum of 8 50 minute periods of supervised class time for research and to **HAND WRITE** the final report.
Re-assessment	There is no further assessment opportunity for this standard.
Authenticity	▪ This report is to be all your own work. No copying. Quotes must be acknowledged and articles cited (bibliography). ▪ You will have to sign an **Authenticity Form** ▪ You will need to submit evidence of your own written notes from the research material you used and submit a draft/s of your report. These will need to be handed in with your final report. ▪ All research material/written notes/drafts used during an assessment period **must be handed to your teacher** at the end of each period. These will be reissued in the next session. ▪ Additional research material may be brought in. It must be shown to your **teacher for approval** and then it is not to be taken out again

.

Appeals	Refer to your NCEA Assessment Handbook.
Resubmission time	20 minutes [your teacher will indicate if you are eligible to resubmit]
Due date and time	**Week 6 Term 3 (your teacher will give exact date & time details)** **Nationwide all reports must be handed in at the end of the last period given for this internal. Nationwide last possible hand in is Friday, 10th October, period 6, 3pm.**

Achievement Standard Science 90954: Demonstrate understanding of the effects of astronomical cycles on planet Earth

Credits: 4

Resourced Title: "Lunar – our Moon"

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of the effects of astronomical cycles on planet Earth.	Demonstrate in-depth understanding of the effects of astronomical cycles on planet Earth.	Demonstrate comprehensive understanding of the effects of astronomical cycles on planet Earth.

Student instructions

Introduction

This assessment activity requires you to comprehensively research and gather information on **at least 2** astronomical cycles of the Moon **and** their effects on Earth – [possible cycles and effects can be found on page 3].

You will have a maximum of 8 x 50 minute lessons to complete this assessment.

Setting

Task

The spin of the Moon, the orbit of the Moon around the Earth, and the orbit of the Moon and Earth around the sun, all have a profound effect on our planet, Earth.

This assessment activity requires you to research and present information in a **HAND WRITTEN** report that shows your understanding of at least TWO astronomical cycles of the Moon and their effects on planet Earth.

A range of resources has been provided on MOODLE (see page 4).The information you use and gather may come from these resources and/or other resources you find independently. You can include images, statistical data, diagrams, and general information but all information must be written in your own words and diagrams must be annotated in your own words and/or redrawn to show your understanding. Straight copy will not be assessed

You must cite all research material used in your report following the Westmount guidelines ('How to write a Bibliography' found on MOODLE)

Within your report it is suggested that you include - :

- **definitions** of astronomical terms like: Moon, Earth, orbit, rotation/ spin, cycle
- **full descriptions** of at least 2 cycle/s of the moon
- **discussion** on how the cycle/s of the moon effect the Earth
- **explanations**, in your own words, to why the effects of the Moon's astronomical cycles have an effect on Earth; ensuring you show the link between the astronomical cycles and the effects on planet

You will be assessed on how well you understand the astronomical cycles and their effects on Earth, as presented in the hand written report. An indicative assessment schedule can be found page 5.

Possible Cycles and Effects

Astronomical cycles

- the spin of the Moon
- the orbit of the Moon around the Earth
- the interaction of the Moon and Earth orbiting the Sun

Effects on the Earth

- formation of tides
- Neap and Spring tides
- phases of the moon
- Lunar eclipse

How does the man in the moon cut his hair?

'E clips it

List of  **MOODLE**

Text Resources **Video Clip Resources**

5 things if we didn't have the moon.docx	Microsoft Word Doc
Apogee and Perigee of the Moon.docx	Microsoft Word Doc
Approval AS90954 resources.pdf	Adobe Acrobat Docu
Blue Moon.docx	Microsoft Word Doc
Eclipses and the Moons orbit.docx	Microsoft Word Doc
How Earth and the Moon interact Changed 12.5.14.docx	Microsoft Word Doc
How the Moon Works.docx	Microsoft Word Doc
If We Had No Moon Changed 12.5.14.docx	Microsoft Word Doc
Lunar Eclipse Compared To Solar Eclipse.docx	Microsoft Word Doc
Lunar Eclipses for Beginners.docx	Microsoft Word Doc
Lunar phase.docx	Microsoft Word Doc
Misconceptions about Tides Changed 12.5.14.docx	Microsoft Word Doc
Moon Tides How affect ocean tides.docx	Microsoft Word Doc
Moon Tides.docx	Microsoft Word Doc
Moon.docx	Microsoft Word Doc
OUR RESTLESS TIDES.docx	Microsoft Word Doc
RASNZ Site moon Phases.docx	Microsoft Word Doc
Spring_and_Neap_tides.pdf	Adobe Acrobat Docu
The Different Kinds of Lunar Eclipse.docx	Microsoft Word Doc
The Moon Cycle.docx	Microsoft Word Doc
The Moon.docx	Microsoft Word Doc
The Ocean's Tides Explained.docx	Microsoft Word Doc
Tides -Oceanography.docx	Microsoft Word Doc
Tides.pdf	Adobe Acrobat Docu
Understanding moon phases.docx	Microsoft Word Doc

Tides

Hewitt-Drew-it! PHYSICS 48.Ocean ...	MP4 Video
NASA _ Tidal Forces on Earth.flv	FLV File
Ocean Tides.flv	FLV File
The action of the tides.mp4	MP4 Video

Lunar Eclipse

Eclipse Solar and Lunar.mp4	MP4 Video
explaining solar and lunar eclipse t...	MP4 Video
NASA _ Lunar Eclipse Essentials.mp4	MP4 Video
Solar Eclipse Darkens Queensland _...	MP4 Video
The Earth,Moon and Sun System.m...	MP4 Video
The solar Eclipse in Varanasi Chang...	MP4 Video
Thumbs.db	Data Base File
What Is A Lunar Eclipse_.mp4	MP4 Video
What is an Eclipse (clip).mp4	MP4 Video

Moon Phases

Moon Phases.mp4	MP4 Video
phases of the moon animation.mp4	MP4 Video
Phases of the Moon.mp4	MP4 Video
What Causes The Phases Of The M...	MP4 Video
Why does the moon change shape...	MP4 Video

Student Assessment schedule:

Science 90954 Astronomical Cycles and Their Effects on Planet Earth

<table>
<tr><th>Evidence/Judgements for Achievement</th><th>Evidence/Judgements for Achievement with Merit</th><th>Evidence/Judgements for Achievement with Excellence</th></tr>
<tr><td colspan="3">To achieve well in this achievement standard students must -:
• Communicate the report using a wide range of appropriate (level 1) science vocabulary
• Label any diagrams/ graphs used with their own annotations and relate into the written report (not just cut and paste)
• Explain the concept and use evidence to support the explanation
• Apply understandings of the science to evaluate
• Gather relevant scientific information in order to draw evidence-based conclusions</td></tr>
<tr><td>To gain ACHIEVE:
The student demonstrates understanding of the effect on planet Earth of astronomical cycles of the Moon.

The student researches 2 astronomical cycles of the Moon and the effect/s on planet Earth

The student writes a hand written report that describes 2^+ astronomical cycles of the Moon and describes the link between each cycle and the effect/s on planet Earth.

Example:
Seasons happen because of the tilt of the Earth on its axis. When one hemisphere of the Earth is tilted towards the Sun, it will be summer there. The hemisphere that is tilted away from the Sun will experience winter.</td><td>To gain ACHIEVE with MERIT
The student demonstrates in-depth understanding of the effect on planet Earth of astronomical cycles.

The student researches 2 astronomical cycles of the Moon and the effect/s on planet Earth

The student writes a hand written report that explains how each of the 2 relevant astronomical cycles causes the effect/s on planet Earth.

Example:
The tilt of the Earth on its axis means that as tit travels in an elliptical orbit around the Sun, one half (hemisphere) of the Earth is tilted up towards the Sun while the other half (hemisphere) of the Earth is tilted away from the Sun. The hemisphere that is tilted towards the Sun receives more solar radiation from the sun in set areas.</td><td>To gain ACHIEVE with EXCELLENCE
The student demonstrates comprehensive understanding of the effect on planet Earth of astronomical cycles.

The student researches 2 astronomical cycles of the Moon and the effect/s on planet Earth

The student writes a hand written report that explains in-depth why the relevant 2^+astronomical cycles cause the effect/s on planet Earth.

Example:
Summer temperatures are higher than winter temperatures because the Earth is tilted towards the Sun. This half of the Earth is in the Sun's light for longer (day is longer) and so this half of the Earth heats up and has higher temperatures. The range of temperatures between night and day in summer is not as great as in winter, due to the Earth releasing the stored solar radiation as heat energy during the short nights.</td></tr>
</table>

APPENDIX E

AS90943: Achievement Standard

Subject Reference		Science 1.4			
Title		Investigate implications of heat for everyday life			
Level	1	**Credits**	4	**Assessment**	Internal
Subfield	Science				
Domain	Science - Core				
Status		Registered	**Status date**		30 November 2010
Planned review date		31 December 2016	**Date version published**		12 December 2013

This achievement standard involves investigating implications of heat for everyday life.

Mutual exclusion exists between this standard and AS90939.

Achievement Criteria

Achievement	Achievement with Merit	Achievement with Excellence
• Investigate implications of heat for everyday life.	• Investigate, in depth, implications of heat for everyday life.	• Investigate, comprehensively, implications of heat for everyday life.

Explanatory Notes

1 This achievement standard is derived from *The New Zealand Curriculum*, Learning Media, Ministry of Education, 2007, Level 6. It is aligned with the Nature of Science and the Physical World strands, and is related to the material in the *Teaching and Learning Guide for Science*, Ministry of Education, 2010 at http://seniorsecondary.tki.org.nz.
This standard is also derived from Te Marautanga o Aotearoa. For details of Te Marautanga o Aotearoa achievement objectives to which this standard relates, see the Papa Whakaako.

2 *Implications of heat* may relate to issues involving individuals, groups of people, society in general, the environment, or natural phenomena.

3 *Investigate* involves showing awareness of how science is involved in an issue that students encounter in their everyday lives. This requires at least one of the following:
- the collection of primary evidence from an investigation and relating it to the scientific theory relevant to the issue
- the collection of secondary data and the identification of the scientific theory relevant to the issue under investigation. The issue must involve two different views, positions, perspectives, arguments, explanations, or opinions.

4 *Investigate, in depth,* involves providing reasons for the way science is involved in this issue. This requires at least one of the following:
- the collection of primary evidence from an investigation and relating it to the scientific theory relevant to the issue in order to give an explanation of the issue being investigated
- the collection of sufficient relevant secondary data and the application of the identified scientific theory relevant to the issue to explain the different views, positions, perspectives, arguments, explanations, or opinions of the issue under investigation.

5 *Investigate, comprehensively,* involves providing reasons and linking them in a way that clearly explains the science that is involved in this issue. This requires at least one of the following:
- the collection of primary evidence from an investigation and relating it to the scientific theory relevant to the issue in order to give a comprehensive and critical explanation of the issue being investigated
- the collection of sufficient relevant secondary data and the application of the identified scientific theory relevant to the issue to critically evaluate the different views, positions, perspectives, arguments, explanations, or opinions of the issue under investigation.

6 *Aspects of heat* may be chosen from, but are not limited to temperature, heat energy, specific heat capacity, conduction, convection, radiation, insulation, phase changes, latent heat, the relationships that are relevant to the investigation.

7 The procedures outlined in *Safety and Science: A Guidance Manual for New Zealand Schools*, Learning Media, Ministry of Education, 2000, must be followed during any practical component of the investigation.

8 Conditions of Assessment related to this achievement standard can be found at www.tki.org.nz/e/community/ncea/conditions-assessment.php.

Replacement Information

This achievement standard replaced unit standard 8767.

Quality Assurance

1 Providers and Industry Training Organisations must be accredited by NZQA before they can register credits from assessment against achievement standards.

2 Accredited providers and Industry Training Organisations assessing against achievement standards must engage with the moderation system that applies to those achievement standards.

Accreditation and Moderation Action Plan (AMAP) reference 0233

APPENDIX F

AS90926: Achievement Standard

Subject Reference		Biology 1.2			
Title		Report on a biological issue			
Level	1	**Credits**	3	**Assessment**	Internal
Subfield	Science				
Domain	Biology				
Status		Registered	**Status date**		30 November 2010
Planned review date		31 December 2016	**Date version published**		12 December 2013

This achievement standard involves collecting and processing data and/or information to report on a biological issue.

Achievement Criteria

Achievement	**Achievement with Merit**	**Achievement with Excellence**
• Report on a biological issue.	• Report in depth on a biological issue.	• Report comprehensively on a biological issue.

Explanatory Notes

1 This achievement standard is derived from *The New Zealand Curriculum*, Learning Media, Ministry of Education, 2007, Level 6. It is aligned with the Participating and Contributing achievement objective in the Nature of Science strand, and is related to the material in the *Teaching and Learning Guide for Biology*, Ministry of Education, 2010 at http://seniorsecondary.tki.org.nz.
This standard is also derived from Te Marautanga o Aotearoa. For details of Te Marautanga o Aotearoa achievement objectives to which this standard relates, see the Papa Whakaako.

2 *Report* involves:

- refining a given or agreed question or purpose
- describing the biological ideas that are related to the question or purpose
- collecting and processing primary or secondary data and/or information from a range of sources
- taking a position on the issue
- presenting findings.

3 *Report in depth* involves:

- refining a given or agreed question or purpose
- explaining the biological ideas that are related to the question or purpose
- collecting and processing primary or secondary data and/or information from a range of sources
- identifying at least two different points of view supported by evidence
- taking and justifying a position on the issue
- presenting findings.

4 *Report comprehensively* involves:

- refining a given or agreed question or purpose
- identifying multiple links between the biological ideas that are related to the question or purpose
- collecting and processing primary or secondary data and/or information from a range of sources
- evaluating sources of information/data in respect to the question or purpose
- identifying at least two different points of view supported by evidence
- taking and justifying a position on the issue with a recommendation for action
- presenting findings.

5 An *issue* is a subject on which people hold different opinions or viewpoints. The biological ideas and processes related to the issue must be derived from the Living World strand, Level 6 of *The New Zealand Curriculum*.

6 Data or information for processing must be collected from a range of sources. Sources may be provided to the student. Sources of data and information must be recorded in a way that can be accessed by others.

7 *Processing* information could involve listing, sorting, collating, highlighting, or summarising relevant scientific information.

8 Conditions of Assessment related to this achievement standard can be found at www.tki.org.nz/e/community/ncea/conditions-assessment.php.

Quality Assurance

3 Providers and Industry Training Organisations must have been granted consent to assess by NZQA before they can register credits from assessment against achievement standards.

4 Organisations with consent to assess and Industry Training Organisations assessing against achievement standards must engage with the moderation system that applies to those achievement standards.

Consent and Moderation Requirements (CMR) reference 0233

APPENDIX G

AS90954: Achievement Standard

Subject Reference		Science 1.15			
Title		Demonstrate understanding of the effects of astronomical cycles on planet Earth			
Level	1	**Credits**	4	**Assessment**	Internal
Subfield	Science				
Domain	Science - Core				
Status		Registered	**Status date**		30 November 2010
Planned review date		31 December 2016	**Date version published**		12 December 2013

This achievement standard involves demonstrating understanding of the effects of astronomical cycles on planet Earth.

Achievement Criteria

Achievement	Achievement with Merit	Achievement with Excellence
• Demonstrate understanding of the effects of astronomical cycles on planet Earth.	• Demonstrate in-depth understanding of the effects of astronomical cycles on planet Earth.	• Demonstrate comprehensive understanding of the effects of astronomical cycles on planet Earth.

Explanatory Notes

1 This achievement standard is derived from *The New Zealand Curriculum,* Learning Media, Ministry of Education, 2007, Level 6. It is aligned with the Astronomical Systems achievement objective in the Planet Earth and Beyond strand, and the Nature of Science strand, and is related to the material in the *Teaching and Learning Guide for Science*, Ministry of Education, 2010 at http://seniorsecondary.tki.org.nz.
This standard is also derived from Te Marautanga o Aotearoa. For details of Te Marautanga o Aotearoa achievement objectives to which this standard relates, see the Papa Whakaako.

2 *Demonstrate understanding* involves describing astronomical cycles and the effects on planet Earth using information, visual representations, and data.

3 *Demonstrate in-depth understanding* involves explaining astronomical cycles and the effects on planet Earth using information, visual representations, and data.

4 *Demonstrate comprehensive understanding* involves explaining thoroughly links between astronomical cycles and the effects on planet Earth using information, visual representations, and data. It may involve elaborating, applying, justifying, relating, evaluating, comparing and contrasting, or analysing.

5 *Astronomical cycles* are:

- Spin of the Earth

- Orbit of Earth around Sun
- Orbit of Moon around Earth
- Effect of the Earth's tilt and the heating effect of the Sun.

6 *Effects on planet Earth* may be selected from:

- Day and night
- Seasons
- Changes of temperature during the day and night
- Seasonal changes at the North and South poles, latitude of New Zealand, Tropics of Cancer and Capricorn, and the Equator
- Formation and direction of winds in the Southern hemisphere - direction of surface ocean current flows in the Pacific Ocean
- Phases of the Moon
- Formation of tides
- Neap and Spring tides.

7 Conditions of Assessment related to this achievement standard can be found at www.tki.org.nz/e/community/ncea/conditions-assessment.php.

Replacement Information

This achievement standard replaced AS90192.

Quality Assurance

5 Providers and Industry Training Organisations must be accredited by NZQA before they can register credits from assessment against achievement standards.

6 Accredited providers and Industry Training Organisations assessing against achievement standards must engage with the moderation system that applies to those achievement standards.

Accreditation and Moderation Action Plan (AMAP) reference 0233

APPENDIX H

AS90943: Heat Transfer Unit Plan

L1 Science Unit Plan– AS1.4 – Implications of Heat

Lesson Overview

Week	Monday	Wednesday	Thursday	Friday
8	1. Heat and temperature	2. Conduction	3. Convection	4. Radiation
9		5. Insulation	6. Field trip	7. House plans
10	8. Combining all the ideas together	Assessment Day - 1	Assessment Day - 2	Assessment Day – 3 (Swimming sports)
11	Assessment Day - 4	Assessment Day - 5	Assessment Day - 6	Assessment Day - 7
12	Assessment Day - 8			

Lesson 1:
Students understand the difference between heat and temperature.
Reading exercise to introduce the topic
Discussion around issues and consequences of insufficient heating.

Lesson 2:
Demo – Conduction ring
Theory about how heat energy is transferred along solid objects
Role play demonstrating heat transfer

Lesson 3:
Experiment: Permanganate in beaker that is heated on one side
Convection notes
Worksheet

APPENDIX I

AS90926: Biodiversity Unit Plan

BIO 1.2 Biosecurity

Biology Level 1 **Year 11|Science|High School|2014**
Friday, 20 June 2014, 11:29AM

Unit: BIO 1.2 Biosecurity (Week 18, 4 Weeks)
Achievement Objectives

Science, Level 5, Nature of Science
Communicating in science

- Apply their understandings of science to evaluate both popular and scientific texts (including visual and numerical literacy).

Participating and contributing

- Develop an understanding of socio-scientific issues by gathering relevant scientific information in order to draw evidence-based conclusions and to take action where appropriate.

Science, Level 5, Living World
Ecology

- Investigate the interdependence of living things (including humans) in an ecosystem.

Science, Level 6, Living World
Ecology

- Investigate the impact of natural events and human actions on a New Zealand ecosystem.

NCEA Achievement Standards, Level 1, Biology
Achievement Standards
90926 Report on a biological issue

Enduring Understanding	**Essential Questions**
Students develop an understanding of socio-scientific issues by gathering relevant scientific information. Evidence-based conclusions are drawn from research. Students are able to make recommendations for action, based on research. Students understand that biosecurity is an important issue for New Zealand	• What makes a biology topic an issue? • How do I form a research question from my issue? • Is there relevant data available for my research topic? • Is my data from reliable sources? • What are the different points of view on my issue? • Have I presented my data in an unbiased manner? • What stance am I going to take on this issue and have I validated it? • My recommendation for action on this issue is based on research, not emotion.
Enduring Understanding	**Essential Questions**

Students develop an understanding of socio-scientific issues by gathering relevant scientific information. Evidence-based conclusions are drawn from research. Students are able to make recommendations for action, based on research. Students understand that biosecurity is an important issue for New Zealand	• What makes a biology topic an issue? • How do I form a research question from my issue? • Is there relevant data available for my research topic? • Is my data from reliable sources? • What are the different points of view on my issue? • Have I presented my data in an unbiased manner? • What stance am I going to take on this issue and have I validated it? • My recommendation for action on this issue is based on research, not emotion.

Rural High School Learner Profile	
• Thinking • Using Language, symbols and texts • Managing self	• Inquirers • Knowledgeable • Thinkers • Open-minded • Balanced
Principles	**Values**
• High expectations • Learning to learn • Future focus	• Excellence • Innovation, Inquiry and Curiosity • Integrity • Respect
Knowledge	**Skills**
• biological issues can be presented from different viewpoints • research can be presented in a biased manner • in order to make an informed conclusion or recommend an action, an issue must be researched from all different viewpoints • justification of a stance is simplified if it is backed by valid research • biosecurity is an important issue for New Zealand • breaches of biosecurity impact the New Zealand ecosystem	• know how to develop and refine a research question • be able to research a topic, using multiple sources for information gathering • identify data that is reliable for use in research • present data that is evaluated for bias and/or error, showing different points of view • formulate an opinion based on research and validate a stance taken on an issue • write a report using scientific language • reference sources used in research • produce recommendations for action on an issue

Stage 2 Assessment Evidence

Assessment
1.2 Report on a biological issue
Formative: Written Report
Report on a biological issue

Stage 3 Learning Plan

Learning Activities	Resources
Lesson 1 and 2: Biosecurity Introduce topic and assessment with the Report on a Biological Issue PowerPoint. Go through exemplar material for written reports. Complete Biosecurity Webquest to investigate the general issue of biosecurity in New Zealand and get some ideas for topic. Go through a list of possible topics. Lesson 3: Research questions and referencing Give out assessment task Structured discussion on how to formulate research questions. Students construct individual research questions and get teacher approval. Individual research. Produce biological journals/research scrapbooks as possible repository of Teach students to do **screenshots**. Their journal should be a collection of these. Lesson 4: Using the internet to locate valid information Illustrate valid versus invalid sources using internet. Individual research. Discuss evaluation of information: relevance, age, bias, data and methodology, repeatability Lesson 5: Writing a report Read through and critique examples of student work Lessons remaining Carry out write up. Biological journals/research scrapbooks may be brought in to class. No full texts. No prewritten essays allowed. Open book test conditions apply. **Guidelines for Biology 1.2.doc**	• exemplars from MOE • reference guide from St Peters Library • list of topics that could be researched Book computer suite/library access early! **Introduction** **Possible topics.pptx** **Introductory webquest based on Science Learning Hub. Will take at least 1 period. Suggest teams**
Thinking Tools integrated into this unit	**Differentiated Learning Activities**
• Venn diagram • De Bono six hats	• practice essay if time allows • individual research allows for students to set their own personal challenge

Biosecurity webquest

Follow the instructions below to construct notes that answer the questions.

1. Go to **http://www.sciencelearn.org.nz/Contexts/Hidden-Taonga/Timeline**
2. Construct your own version of this timeline to an appropriate scale.
3. Go to **http://www.sciencelearn.org.nz/Contexts/Hidden-Taonga/Looking-Closer/New-Zealand-s-unique-ecology**
4. Read the article and summarise the geological and biological processes that have made New Zealand unique
5. Go to **http://www.sciencelearn.org.nz/Contexts/Hidden-Taonga/Looking-Closer/Protecting-New-Zealand-s-treasures**
6. Define the terms: native, endemic, endangered, extinct, habitat and ecosystem.
7. Use the article to outline how the Haast Eagle was brought to extinction
8. Go to **http://www.sciencelearn.org.nz/Science-Stories/Conserving-Native-Birds/Protecting-native-birds**
9. Read the article. Past breaches of biosecurity have had catastrophic impacts on native populations. Explain three ways that DOC is trying to reverse the damage done.
10. Go to **http://www.sciencelearn.org.nz/Contexts/Hidden-Taonga/Looking-Closer/Conserving-New-Zealand-s-fungi**
11. Read the article and write a paragraph stating your opinion on whether *Puccinia embergeriae* should be conserved or not. Justify your opinion.
12. Go to **http://www.sciencelearn.org.nz/Contexts/Saving-Reptiles-and-Amphibians/NZ-Research/Saving-Reptiles-and-Amphibians**

13. Read the article

14. Go to **http://www.sciencelearn.org.nz/Contexts/Saving-Reptiles-and-Amphibians/Science-Ideas-and-Concepts/Threats-to-native-reptiles-and-amphibians**
15. List the threats to New Zealand reptiles and amphibians and give an example of each. Put them in order of which you think is likely to have the biggest to smallest impact on New Zealand.
16.

Use the internet to answer the following questions.

17. What is biosecurity?
18. What organisation is responsible for biosecurity in New Zealand?
19. What activities are carried out to maintain Biosecurity?
20. What breaches of biosecurity have happened in the last 3 years? What have the impacts of these been? How were they managed?
21. List 5 items that are not allowed to be brought across the New Zealand border for the purposes of biosecurity. Give the reason why each of them is not allowed in.

APPENDIX J

AS90954: Lunar Unit Plan

<u>Suggested Teaching Programme - Internal AS 90954</u> – Astronomical Cycles and Effect on Earth

		Lesson		Focus	Suggested Activity
Week 1		1		Recall Year 10 terminology	• astronomical terms – universe, galaxy, stars, sun, constellations, solar system, planets, moons, meteors • Solar System – planets, order, terrestrial/ gaseous, gravities, temps., astronomical features
		2			
		3			
		4			
Week 2		1		Identify what a moon is Identify the 3 astronomical cycles between Earth and Moon - Spin of the Moon and Earth - Orbit of Moon around Earth - Orbit of Moon & Earth around Sun Explain the effects of the cycles in Earth in terms of -: - tides - Neap and Spring tides - Moon phases - Lunar Eclipse	• Observe, plot and/or research tidal movement daily / month /year (from newspaper, internet, observation at the wharf) • Draw diagram to show formation of tides (on both side of Earth) High and Low tide • Draw sun, Moon Earth diagram to show difference between normal , neap and spring tides • Observe the moon phases with relation to sun earth and moon using dark room , light (=sun) small ball covered in foil (= moon) and Earth larger ball. • Students perform rotation and orbiting of Moon. Include how this is involved in moon phases • Identify or label a diagram to show the moon phase • Label diagram showing plane and movement of moon around Earth to include Moon's rotation. Acknowledge 'dark side of the moon' • Draw diagram to show position of Moon, Earth and Sun when in a Lunar Eclipse. • Label diagram with the two (three) distinct parts of a shadow,with **umbra**, **penumbra** and (**antumbra** *optional*) • Observe animations of moon rotation and orbits (when approved by SLO)
		2			
		3			
		4			
Week 3		1			
		2			
		3			
		4			
Week 4		1	INTERNAL		Clarify -: • What are Astronomical cycles and what are effects on Earth • How to write a Bibliography
		2		Research	Read, research, collate notes on -: • 2^{+} astronomical cycles • 1^{+} effects on Earth
		3			
		4			
Week 5		5			
		6		Writing Report	Write up draft report
		7			Write up report
		8			Write up report

APPENDIX K

Consent Form & Ethics Approval Letter

Curtin University

Science and Mathematics Education Centre

GPO Box U1987
Perth Western Australia 6845

Telephone +61 8 9266 7924
Facsimile +61 8 9266 2503
Email D.Treagust@curtin.edu.au
Web http://www.curtin.edu.au

Student Information Sheet

Title: Enhancing Students' Learning Experiences Outside School (LEOS) Using Digital Technologies

My name is Sandhya Coll. I am currently doing research for my Doctor of Science Education Programme at Curtin University.

Purpose of research

In my research I am investigating what teachers and students perceive to be the role of out-of-school trips and activities (e.g., visits to museums, zoos, science field trips, etc.) in science teaching and learning and if using digitally supported environments like Moodle could help enhance these science learning experiences.

Your Role

I am interested in finding out if people think we need to include learning experiences outside school like fieldtrips as part of what we do in school and how these might work well with our classroom lessons. I also am interested in what makes such fieldtrips effective and how they might be improved. A key part of my study is to see how we might support such learning experiences with digital technology such as *Moodle* to enhance science learning outcomes. To do this research I want to make some observation of classroom activities; and look at what is in relevant documents such as curriculum material, lesson plans and the like. I would like to conduct interviews with relevant people involved in learning experiences outside school including students, parents, teachers, HOF and Principal, staff from informal science institutions (like zoos and observatory) and look at student work, both written and *Moodle* forum entries. There will be two interviews with students and teachers (before and after any visit). For teachers these will be one-on-one, but for the students these will be focus group interviews for about 15-20 minutes duration. There will only be one interview with HOF and Principal (or any member of SLT), any parents, and any staff from the informal science institutions; again these may take about 15-20 minutes. The above interviews will be recorded and interview transcriptions typed up by me. Teachers and students also will be asked a few questions during the off site visits. These will not be recorded but I will make written field notes to record answers. Observations of classes and field trips will not be videotaped, only written field notes will be made.

Consent to Participant

Your involvement in this research is entirely voluntary. You have the right to withdraw at any stage without it affecting your rights or my responsibilities. When you have signed the consent form, I will assume that you have agreed to participate and allow me to use your data in this research.

Confidentiality
The information you provide will be kept separate from your personal details, and only myself and my supervisor will have access to this. The interview transcriptions will not have your name or any other identifying information on it and in adherence to University policy, the interview tapes and transcribed information will be kept in a locked cabinet for at least five years, before they are securely destroyed. Field note data from observations also will be secured in the way described above.

Further Information
This research has been reviewed and given approval by Curtin University of Technology Human Research Ethics Committee (Approval Number **SMEC-53-12**). If you would like further information about the study, please feel free to contact me on (021 2944 789 / (07)843 8989) or my email s.coll@postgrad.curtin.edu.au . Alternatively, you can contact my supervisor Professor David Treagust on (+618) 9266 7924 or email D.Treagust@curtin.edu.au .

Thank you very much for your involvement in this research.
Your participation is greatly appreciated

CONSENT FORM

- I understand the purpose and procedures of the study.
- I have been provided with the participation information sheet.
- I understand that the procedure itself may not benefit me.
- I understand that my involvement is voluntary and I can withdraw at any time without problem.
- I understand that no personal identifying information like my name and address will be used in any published materials.
- I understand that all information will be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.
- I have been given the opportunity to ask questions about this research.
- I agree to participate in the study outlined to me.

Name: ______________________

Signature: ___________________

Date: ________________________

Curtin University

Office of Research and Development
Human Research Ethics Committee
TELEPHONE 9266 2784
FACSIMILE 9266 3793
EMAIL hrec@curtin.edu.au

MEMORANDUM

To	Sandhya Coll, SMEC
From	Mun Yin Cheong, Form C Ethics Co-ordinator, Faculty of Science and Engineering
Subject	Protocol Extension Approval **SMEC-53-12**
Date	21 November 2014
Copy	David Treagust, SMEC

Thank you for keeping us informed of the progress of your research. The Human Research Ethics Committee acknowledges receipt of your progress report for the project "Enhancing students' Learning Experiences outside School (LEOS) using digital technology".

Approval for this project is extended to **9th December 2016.**

Your approval has the following conditions:

(i) Annual progress reports on the project must be submitted to the Ethics Office.

Your approval number remains **SMEC-53-12**. Please quote this number in any further correspondence regarding this project.

Yours sincerely

Mun Yin

MUN YIN CHEONG
Form C Ethics Co-ordinator
Faculty of Science and Engineering

APPENDIX L

Interview and Observation Protocol

Pre-visit Preparation			
Classroom Observation	**Teacher Interview**	**Focus Group Interview**	**ISI staff Interview**
1. How is the topic related to the visit taught in the classroom? 2. What specific activities were done prior to the visit? 3. Were students involved in decision making for this visit? 4. Were the students informed about the purpose of the visit? 5. Were the students clear as to what was expected of them on the visit? 6. What specific preparations were done to take students out of this school-school and ISI applications?	1. Can you tell me what the main purpose of the visit is? 2. Can you tell me what you had to do to justify the visit? 3. Can you tell me what procedures are undertaken to gain approval for the visit? 4. Can you tell me what activities you have planned prior of the visit? 5. Can you tell me who will be accompanying you on this visit? 6. Can you tell me what role you see these people fulfilling? 7. What training / instructions have you provided to these people/parents? 8. What contact have you had with staff from the Informal Science Institution? 9. Can you tell me what activities you have planned after the visit?	1. Can you tell me what you think is the main purpose of the visit? 2. Can you tell me what activities you have done prior of the visit? 3. Can you tell me what activities you think are planned after the visit? 4. What were some of the things you most enjoy about this trip? 6. Do you think there are things which should be changed? Why? 7. Is there anything else you would like to mention about this trip? 8. Was any work done via Moodle pre-visit- if yes what were they? 9. Can Moodle be used for collaboration between students-how? 10. Do you think Moodle forum and wiki can be used to help you learn the topic better- if yes how?	1. What contact did you have with the teacher before the visit? 2. What activities do you have planned? 3. How do you think the trip went? Explain. 4. Are there things which need to be relooked at? What are these and why should they be reconsidered? 5. If students want to get back in touch with you, how do you think you will be able to facilitate these communications?

<table>
<tr><th colspan="4">During the Visit</th></tr>
<tr><td colspan="4">1. What specific activities were done during the visit to the ISI?
2. What interaction did the students have with ISI staff?
3. What interaction did the students have with the teacher?
4. What interaction did the students have with parents/helpers?
5. What interaction did the students have with other students?</td></tr>
<tr><th colspan="4">Post-Visit Findings</th></tr>
<tr><th>Classroom Observation</th><th>Teacher Interview</th><th>Focus Group Interview</th><th>ISI staff Interview</th></tr>
<tr><td>1. What specific activities were done after the visit?
2. Were any activities done after the visit related to the classroom lessons?</td><td>1. How did you think the visit went?
2. What do you think your students learned?
3. How do you think they learned that?
4. How do you know they learned that?
5. Was there any opportunities for free choice learning at the ISI? If so, what were they?
6. Did you use wiki and forum before and after the trip? If so how were these used?
7. How do you think students perceived this medium of communication?
Why do you think this was so?
8. What did you see your role in these forums? How did you engage the learners?
9. Do you think the use of LEOS and Moodle collaboration helps enhance the learning of science? How do you know this?
10. If you were asked to teach this topic again, what changes will you do if any to your lesson planning and delivery?</td><td>1. Did you enjoy the visit?
2. What do you think you learned?
3. How did you learn that?
4. How do you know you learned that?
5. What activities were done after you all returned from the site visit?
6. Was any work done via Moodle post-visit- if yes what were they?
7. Can Moodle be used for collaboration between students- how?
8. Do you think Moodle forum and wiki can be used to help you learn the topic better- if yes how?</td><td>1. How did you think the visit went?
2. What do you think the students learned?
3. How do you think they learned that?
4. How do you know they learned that?</td></tr>
</table>

APPENDIX M

Report on Current Practices in LEOS

Date: 15 January 2014
To: Ms Harris, Head of Faculty of Science, *Rural High School*
From: Mrs Sandhya Coll, Curtin Science & Mathematics Centre, University of Technology

Learning Experience Outside School (LEOS): Pest Ecology- Investigating the Rat Population in the Rural High School Community and Pest Impacts on Maungatautari.

In this report, I wish to share the following:

1. What the literature has to say about maximising learning outcomes from LEOS generally;

2. The observations I had made during and after the fieldtrip (from-field observations, student and staff interview and student reports); and

3. Conclusions and some recommendations.

1. Maximising Learning Outcomes from LEOS

Student learning in Informal Science Institutions (ISIs) is an excellent way to enrich students learning experiences, motivate them to learn science, encourage lifelong learning and also expose them to future careers (Bamberger & Tal, 2007; Hofstein & Rosenfeld, 1996; Tal, 2012). Since these informal settings are idiosyncratic, learning occurring at these sites depends on the students' personal and social context in which learning takes place (Rennie & Johnston, 2007). There are four learning outcomes of ISIs reported in the literature:

1. Improved development and integration of scientific concepts;
2. Social outcomes such as collaborative work and responsibility of learning;
3. Access to non-school material and 'big' science; and
4. Improving attitude to school science and stimulating further learning (Braund & Reiss, 2006).

The key to deriving the most from LEOS is when learning is facilitated by pre-planning and post-visit activities - all linked directly and integrated with curriculum objectives (Rennie & McClafferty, 1995; Tofield et al., 2003). This structure for learning gives meaning to abstract science ideas studied in the classroom (Anderson, Lucas, Ginns & Dierking, 2000; Orion & Hofstein, 1994). This suggestion is consistent with other research which emphasizes the importance of careful planning in order to move learning beyond the surface learning of facts or content (Hooper-Greenhill, 2000; Kisiel, 2003).

2. Observations made from LEOS

Some observations made from these interviews with both staff and students alike and from field notes gathered on Monday 02 December 2013, suggested the following:

A. *Pre-visit*: Students in Year 10 studied a topic on 'Pest Ecology' where they worked in groups and collected data from the tracking tunnels (pre-designed boards with peanut butter and black ink) which were set up around their school. The pests which reportedly visited these sites were feral cats, rats, stoats and ferrets. The data were collected from each class and pooled which were then used by students to write their interim reports. It seemed that visiting Maungatautari was to provide them with an insight to what was being done on a larger scale to control the pest population. It was intended from teacher planning that the LEOS should complement classroom teaching since the students were asked to use the data collected from the ISI in order to complete their final report on this topic. It was interesting to note that all liaisons between the ISI and the school were conducted via the Teacher-in-Charge only without involving other teaching staff of this year group. This was reported to be the traditional practice of this school.

B. *During Visit*: It was difficult to identify much interaction between students on the topic under study. Students mainly discussed camping trips which they had been on recently. Additionally, the teachers played a largely passive role while on the site. ISI staff asked all the questions but seldom allowed students any opportunities to make inquiries during these demonstrations which are consistent with the literature. It seemed that there was very little note taking, if any, conducted by students with occasional photographs taken. Most did complete their reports since they had already completed this task earlier during the year. The introduction session by the ISI staff was reported by most students to be something they already knew while other students displayed enthusiasm towards some components of the presentation, especially the slides showing maps of the Island Ecological Reserve. Some students were highly impressed by the different types of traps used which were different to the ones they knew about. The students were not given opportunities to make any inquiries during the introductory presentation or by their guide. Students said they enjoyed seeing Takahe and Tuatara and visiting the tower to see the top of the tress.

C. *Post-visit*: Students reported that such experiences allowed them to develop a better understanding of the science taught in the classrooms and relate this to experiences around them. Furthermore, they felt that the learning at ISIs helped improve their attitude to school science and interest in further learning. For example, a group of students decided to look for opportunities to work as volunteers at this ISI. They also reported that it increased their motivation, interest, and improved attitude towards the topic. One of the teachers provided copies of final report of the expected outcomes from this visit. However, this was only possible in this one case since this teacher had the opportunity to visit the ISI earlier with her students as well as had the time to integrate learning.

3. Conclusions and Recommendations

As noted above, ISIs has huge potential for informal learning, where student learning is self-paced and self-directed. Non-school material and 'big science' is a key facet of learning opportunities at ISIs. Learning in ISIs is different from that in a classroom, and if we are to maximise such opportunities, we need to do the following:

1. The key to deriving the most from LEOS is when learning is facilitated by pre-planning and post-visit activities - all linked directly to curriculum. That is, teachers should ensure that when teaching a specific topic which requires field based experience, some lessons should be completed in the classroom which provides the scope for the study, specific tasks for students which needs to be completed at the ISI, and specific activities which need to be completed using those findings when they return to classroom;
2. The objectives of the trip should be strongly linked with classroom teaching and students should be informed of these as well as what they are expected to do at the ISI. That is, teachers should prepare the classroom lessons in a way which provides students with adequate knowledge and understanding of what are the specific expectations (e.g., learning activities) from their visit to the ISI;
3. The tasks designed to facilitate learning in LEOS should draw upon students' prior experience and knowledge, and allow some freedom of choice – for example allowing students to choose some particular pests they wish to explore in-depth;

4. Trips to ISIs should be planned concurrently to the topic being taught and not left to the end of the year. This will ensure that there is enough time for the post-visit activities described above to be completed;
5. The ISI staff should be informed of the objectives of the visit in order to prepare for targeted activities as well as group discussions. This ensures the students interact with the ISI staff (both guides and the presenters) instead of just listening to a pre-planned presentation;
6. Collaborative knowledge building and taking responsibility for learning are some of the objectives of informal learning conducted during and after LEOS. I recommend the use of the learning management system, MOODLE, to assist in this collaboration, and this will be the focus of my intervention this year – something I am happy to facilitate.

APPENDIX N

Validation of Findings

Validation of Data

Thesis: Sandhya Coll

Title: Enhancing Students Learning Experiences Outside School (LEOS) Using Digital Technologies

Date: Friday 31 October 2014

I am pleased that our school was chosen for this inquiry. Sandhya is well known to my staff and students because she has assisted us in judging our IB Year 12 programmes. To have an independent audit of the classroom practices is always appreciated by the teachers of our faculty as well as the Senior Leadership Team. It gives us an insight to areas which needs improvement.

I have read the chapters of Sandhya's Thesis where she provides an insight of the current practices we had at our school. She is correct in saying that the field trips at the end of the year for students in Years 9 and 10 were only to keep them occupied. The senior classes were away on camping trips and all teaching had been concluded across the school. It is also a busy time for most of the senior teachers as they are involved in planning and preparing for the following year.

We were surprised to find that there was no LEOS integrated teaching at the senior science levels. While Sandhya helped us in choosing the topics for her inquiry, we did not want to disrupt the teaching lessons of any other subjects; hence all topics chosen were only internally assessed.

The interviews and feedbacks from other staff and students were equally encouraging. While we found that students were keen to take up collaborative learning via Moodle, the teachers were rather reluctant to use this interphase. We do need more workshops in this area, but we feel that Sandhya has given us some good insight when she prepared for the intervention part of her inquiry.

Through Moodle posts, classroom observations, teacher and students workbooks, and the focus-group interview, Sandhya was able to accurately establish the level of understanding the students had when they did not experience any learning outside the school. She also had the students suggest changes to be made to the way the ISI visits were to be prepared. I truly enjoyed the idea of including free choice learning because it started more discussions between students and between students and ISI staff. We also included our School Career Advisor in one of the trips, who equally enjoyed the experience.

The conclusions drawn by Sandhya from the data she has collected is sound and well thought through. As with any of this type of research, the types of students will always vary, but we need to integrate digital technologies such as Moodle across other subject areas also, so that students get a better understanding of this tool.

Ms. Harris

HOF Science

Rural High School

New Zealand

APPENDIX O

Year 10 Ecology Unit Plan

Ecology

Unit Map 2013

Monday, 21 October 2013, 2:33PM

Unit: Ecology (Week 22, 5 Weeks

<table>
<tr><td colspan="2">Stage 1 Desired Results</td></tr>
<tr><td colspan="2">Achievement Objectives
Science, Level 5 , Nature of Science
Understanding about science

▪ Understand that scientists' investigations are informed by current scientific theories and aim to collect evidence that is interpreted through processes of logical argument.

Investigating in science

▪ Show an increasing awareness of the complexity of working scientifically, including recognition of multiple variables.

Participating and contributing

▪ Develop an understanding of socio-scientific issues by gathering relevant scientific information in order to draw evidence-based conclusions and to take action where appropriate.

Science, Level 5 , Living World
Life processes

▪ Identify the key structural features and functions involved in the life processes of plants and animals.

Ecology

▪ Investigate the interdependence of living things (including humans) in an ecosystem.

Evolution
Describe the basic processes by which genetic information is passed from one generation to the next.</td></tr>
<tr><td>Enduring Understanding</td><td>Essential Questions</td></tr>
<tr><td>Understand basic ecological principles and develop attitudes and positive actions towards the fragile nature of New Zealand's biodiversity.</td><td>1. How are organisms interdependent on one another and their environment?

2. What is biodiversity and why is it important to conserve it?</td></tr>
</table>

Rural High School Learner Profile	
▪ Thinking ▪ Participating and contributing	▪ Inquirers ▪ Knowledgeable ▪ Principled ▪ Caring ▪ Reflective
Principles	**Values**
▪ Future focus — Why is sustainability important?	▪ Ecological sustainability ▪ Integrity
Knowledge	**Skills**
Define ecology as the study of organisms and their relationship to each other and their surroundings. Define adaptations as features that help an organism to survive and reproduce. Differentiate between structural, physiological and behavioural adaptations. Define a...Species as a group of organisms that can reproduce together to produce fertile offspring. Population as organisms of the same species living in the same place. Community all the living things living in a particular area. Ecosystem all the living things (community) and the physical conditions in a particular area. Describe niche as an animal's habitat, feeding role, and adaptations it has that enable it to carry out its "job" in its habitat. Define different feeding roles, producer, consumers and decomposers. Define biodiversity Recognise organisms are controlled by genetically controlled characteristics. List and differentiate between biotic and abiotic factors in an ecosystem Understand the carbon cycle. Understand the processes of Photosynthesis and respiration. Understand how different organisms contribute to these cycles.	Construct food chains and webs from the information gathered by the class. Keeping organisms alive in a vivarium. Following scientific protocols for monitoring organisms / change over time. Draw basic representations of the carbon cycle. Construct energy flow diagrams using appropriate organisms. Identify trophic levels in webs and chain.

Stage 2 Assessment Evidence	
Assessment Ecology Test Summative: Written Test	
Learning Activities	**Resources**
LESSON 1: Investigate and photograph examples of plants and animals that inhabit an ecosystem. E.g. Kahikatea stand. Use the organism as a context for the following learning. Use mind maps to define Ecology (prior knowledge) LESSON2: Organisms, animals or plant material can be collected within reason or better still photographed for further study. Organisms can be kept in separate school vivariums for a week and then returned "unharmed" to their natural habitat. LESSON 3:Define adaptations as features that help an organism to survive and reproduce. Differentiate between structural, physiological and behavioural adaptations. LESSON 4: Define a... Species as a group of organisms that can reproduce together to produce fertile offspring. Population as organisms of the same species living in the same place. Community all the living things living in a particular area. Ecosystem all the living things (community) and the physical conditions in a particular area. LESSON 5-6: Describe niche as an animal's habitat, feeding role, and adaptations it has that enable it to carry out its "job" in its habitat. Understand organisms have different feeding roles, producer, consumers and decomposers. LESSON 7: Recognise the progress of the restoration project and the schools involvement. Construct food chains and webs from the	1. Pathfinder Y10 2. Pitfall traps (in Kaihikatea) 3. Kiwi in crisis(worksheet) 4. Unwelcome visitors(worksheet) 5. Harakeke - Our Native Flax (worksheet) 6. Click view: The Pond - Community in action. 7. Videos-Sanctuary Keepers, Invaders in paradise, Ghosts of Gondwana Niche examples Overview Adaptations FEEDING ENERGY FLOW AND RECYCLING.doc FEEDING BIODIVERSITY oht and expt.doc

information gathered by the class. LESSON 8: Identify trophic levels in webs and chain. Recognize that all food chains start with producers and end with decomposers. Construct energy flow diagrams using appropriate organisms. Describe biomass as amount of substance animal is made of. LESSON 9-10: Understand that the more biodiversity there is in an ecosystem the more stable it will be. Understand and develop attitudes about the fragile nature of New Zealand's biodiversity. Understand the need to conserve biodiversity and how humans can have a positive effect. Recognise the need to monitor the changes in an ecosystem over time so that progress can be achieved and for further management. Recognise the need for scientific rigour and standardised protocols when monitoring. Describe examples of sampling methods e.g transects Consider attitudes and actions toward the Kahikatea stand. LESSON 11-12: Identify and evaluate the health of some native populations in New Zealand. Understand that population growth is always limited, and recognise some of these limiting factors. Recognise organisms are controlled by genetically controlled characteristics and that variation is extremely important if a population is subjected to pressures, human or otherwise. Consider attitudes and actions toward N.Z endangered populations. LESSON 13-14: List and differentiate between biotic and abiotic factors in an ecosystem Interpret the effects that biotic and abiotic	

factors have on different organisms. Draw basic representations of the carbon cycle. Understand the processes of Photosynthesis and respiration. Understand the consequences of disrupting these cycles. Understand how different organisms contribute to these cycles. LESSON 15: Identify how the original wetlands food chains have been disrupted by human impacts and the introduction of pests and predators. Recognise the fragile nature of ecosystems, and their susceptibility to change. Understand the importance of sustainability of our resources. Consider attitudes and actions toward pests and predation.	
Thinking Tools integrated into this unit ▪ PMI ▪ Venn diagram ▪ Fishbone ▪ Other PMI- sustainability/ conserving biodiversity Fishbone- Ecology as backbone Venn diagram- biotic and abiotic factors affecting an organism Mind maps - Prior knowledge	**Differentiated Learning Activities** In Groups collect organisms Construct food chains/webs from NZ examples. Set up and compare pitfall traps in comparative ecosystems. Biodiversity website: https://www.biodiversity.govt.nz/involved/index.html Get involved with community restoration projects Virtual field trips: www BIODIVERSITY NZ LEARNZ

APPENDIX P

Risk Analysis and Management System Form

Half / One Day Field Trip

TRIP PROPOSAL AND R.A.M.S

Complete Activity Proposal and RAMS Form

Present the above listed information to Management for trip approval.

Pre-trip Preparation

1. a) Provide parents with a written description of the course activity to take place (Form 1). Mode of transport to be included.
   b) Clearly outline the aims of the field trip.
   c) Identify the staff to be included on trip. State ratio of staff: students.
   d) Request permission to include student on trip.
2. Complete list of students names, parents / guardians contact phone numbers should parents need to be contacted. Place list with Reception and on staff noticeboard.
3. Note the nearest medical and dental centre – record the (emergency phone numbers).
   Approval needed from Deputy Principal (Human Resources) so that relief can be arranged.

EDUCATION OUTSIDE THE CLASSROOM

Half / One Day Field Trip
Field Trip / Off Campus Activity Proposal

Staff Member in Charge: ______________________________

Activity: ____

Date of Trip: ___________________ **Class / Group to be Taken:** _____________________

Number of Students: ___________________ **Assistant Staff:** ______________________________

Parental Consent Given: _________ ______________________________

Ratio of Staff to Students: _______________ ______________________________

Purpose of Trip: Curriculum/Extracurricular **Departure Time:** ___________ **ETA:** _________

Return Time: ______________ **Mode of Transportation:** ________________________________

Person in charge of First Aid: ____________________

Signed: ____

Permission for trip granted / declined

Management ____________________

Phone Contact Numbers:

1. ________________________(Activity Leader)
2. ________________________
3.

Staff Member in Charge: ________________ **Date of Trip:** ________________

Analysis	**Description**					**☐ TICK BOX** **☑ = Planned RAMS / eventuality / procedure**
RISKS Accident,	1. Students getting lost. ☐ 2. Injury of death by vehicle. ☐ 3. Incident due to sickness / medical condition. ☐ 4. Other: *(please specify)* ☐ ______________________					
DANGERS Hazards, Perils	**PEOPLE**		**EQUIPMENT**		**ENVIRONMENT**	
	1. Poor information systems for staff, students & parents re: purpose, plan, procedures, policy, environments, people etc. 2. Poor behaviour – insufficient or inappropriate supervision. 3. Incompetent leadership – planning & implementation. 4. Other *(please specify):* ______________________	☐ ☐ ☐ ☐	1. Faulty transport. 2. Insufficient information re routes and locations. 3. Lack of medication. 4. Inappropriate clothing / footwear. 5. Insufficient food / drink. 6. Activities inappropriate for students. 7. Other *(please specify):* ______________________	☐ ☐ ☐ ☐ ☐ ☐ ☐	1. High density traffic area. 2. Walking too far. 3. Road works – insufficient pedestrian access. 4. Complex city environment. 5. Inclement weather. 6. Other *(please specify):* ______________________	☐ ☐ ☐ ☐ ☐ ☐

RISK MANAGEMENT STRATEGIES	**Normal Operation**	1. Systems, documentation for informing parents, staff, students re: purpose, plan, procedures, policy, environment, people etc. Prepare student appropriately prior to trip with skills and knowledge. 2. Behaviour code re: policy. Buddy students up during activity Have appropriately prepared staff / parents or appropriate adult / student ratio. 3. Know health / physical / behavioural characteristics of participants. 4. Other *(please specify):* __________________	☐ ☐ ☐ ☐	1. Check transport prior to activity. 2. Prepare and present information pack to participants prior to activity. 3. Ensure students have food and drink. 4. Send a gear list and food list to parents / caregivers in sufficient time prior to activity. 5. Check that all students have appropriate clothing & footwear prior to activity. 6. Seek expert advice. Do not proceed. 7. Other *(please specify):* __________________	☐ ☐ ☐ ☐ ☐ ☐ ☐	1. Plan route to avoid high density traffic areas. 2. Plan route with rests to avoid student stress. 3. Know the route re: lights, one-way streets, foot paths etc. Avoid roadworks. 4. In an urban environment have maps, meeting places and time pre-prepared. 5. Have a contingency plan in case of inclement weather. 6. Other *(please specify):* __________________	☐ ☐ ☐ ☐ ☐ ☐

Activity: ________________________________ **Situation:**____________________

RISK MANAGEMENT STRATEGIES	Emergency	Leave contact list at school with Deputy Principal (Human Resources). Give students a plan for *"what to do if you get lost".* ☐ Have an emergency meeting place and time set before activity commences. Know where to go for medical assistance if it is needed. ☐ **EMERGENCY NUMBERS** **Police / Fire / Ambulance: Ph – 111** **Waikato Hospital: Ph – 07 839 8899** **Anglesea Clinic: Ph – 07 858 0800** **Anglesea Clinic Dental Centre: Ph – 07 8580750** **Cambridge Medical Centre: Ph – 07 827 7184**

Half / One Day Field Trip

R.A.M.S

Name: ______________________________ **Date:** _________________

Field trip, activity, situation: ____

____

Students Included on Trip		
Names	**Medical Information**	**Contact Phone number for emergencies**

APPENDIX Q

Year 10 Pest Ecology Project

Pest Ecology Project- Investigating the rat population in the *Rural High School's* community and pest impacts on *Island Ecological Reserve*

Student Instructions Sheet

Aim

To record, process and interpret field data estimating the size of the population of rats and other small animals around *Rural High School* throughout the year and to analyse the impact that removing rats and other pests' species has had on *Island Ecological Reserve*

Rats are one of the several major pests in New Zealand. They negatively impact on the environment, human health and on general appeal.

Conditions

Your class will work in groups to collect data from the tracking tunnels that are set up around the school. This will be done once a week for half a term. At the end of the year, the data from each class will be pooled and you will be given a copy of the data collected throughout the year. You will then have 3 hours to work individually to write a report making a recommendation to the school about pest control. You will also research Island Ecological Reserve to see the impact on pest eradication on the ecosystem.

Task 1: Recording Field Data

This task is to be done in groups of 3-5 people. There will be 6 groups in each class. Each groups will be responsible for maintaining one line of tracking tunnels, recording the data and submitting it to the teacher in the format provided

Task 2 : Island Ecological Reserve Research

This task is to be done individually. Use the libarary and the resources available to answer the following questions:

- Where is the Island Ecological Reserve?
- How big is Island Ecological Reserve?
- Name 4 pest species that were common in Island Ecological Reserve but have been eradicated? How did they know those pests were present and how did they get rid of them?
- Name 3 native plant and 3 native animal species that are currently on Island Ecological Reserve?
- Explain the likely outcomes if pests, such as rats, were to get into the enclosure?
- Discuss the history and development of the Island Ecological Reserve?

Task 3: Processing Data

This task is to be individually in class time at the end of the year. Use the data summarising the findings of the Year 10 tracking tunels around the Rural High School to draw a line graph showing how the average percentage abundance of rats changed throughout the year.

RURAL HIGH SCHOOL SNALL ANIMAL *SURVEY USING TRACKING TUNNELS 2013

		Month				
	Location	Feb-March	April - May	June-July	Aug-Sept	Oct-Nov
Average % abundance	Kahikateas	60	80	60 Mice only	80	80
	Horton Gym	80	80	80	80	80
	Academic zone	60	80	60	80	100
	Boys boarding	100 Includes cats	100 Includes cats	60 Includes cats	80 Includes cats	100 Includes cats
	Girls boarding	40 Mice only	60 Mice only	40 Mice only	40 Mice only	60 Mice only
	Total					

* "Small animals" includes rats, mice, hedgehogs, cats and insects

Rural High School **Survey using Tracking Tunnels 2013**

		Month				
	Location	Feb-March	April - May	June-July	Aug-Sept	Oct-Nov
Average % abundance	Kahikateas	60	20	0	20	40
	Horton Gym	60	40	20	30	40
	Academic zone	60	80	40	40	100
	Boys boarding	0	0	0	0	0
	Girls boarding	0	0	0	0	0
	Total					

Task 4: Reporting

This task is to be done individually in class time at the end of the year. Use the information collected in tasks 1, 2 and 3 to produce a report that includes the following:

- The aim of your study
- A brief description of how you collected the data
- A copy of the table of data with an appropriate title
- A line graph of the average percentage abundance of rats throughout the year
- A description of what happens to the rat population throughout the year and an analysis of what might cause this
- A description of pest monitoring and removal strategies at Island Ecological Reserve.
- An explanation on the impact that the removal of pests has had on Island Ecological Reserve ecosystem, and the predicted impact of pets reentering the enclosure.
- A recommendation to the school regarding details of any action you would like to see taken in the Rural High School ecosystem. This should be backed up with the data from the investigation carried out by your year group along with research materials related to Island Ecological Reserve.

Assessment schedule: Investigating the rat population in the ***Rural High School***

To be awarded the grade (A, M or E) the student must meet the holistic judgement statement at the top of the column.

Task	Judgement towards Achievement		Judgement towards Merit		Judgement towards Excellence	
1	The student is able to record and process field data, describe the population of rats over time, and describe a factor that might be causing changes in the rat populations.		The student is able to record and process field data, describe the population of rats over time, and explain how a factor might be causing changes in the rat populations. The student makes a recommendation for action that is consistent with their data.		The student is able to record and process field data, analyse the population of rats over time, and make a convincing argument to support their recommendation for action.	
2	Describes Maungatautari's location, size with map. (Cambridge, Waikato – 47km enclosure, 3400 hectares enclosed					
	Describes 3 native plants and 3 native animals found at Maungatautari (kokako, tui, kiwi, tuatara, Hochstettors frogs, Silver beech, kauri, kingfern, kauri, flax. , kahikatea, totara (other known native species)					
	Outlines 3 pests: rabbits, rats, possum, wasps, stoats (any other known pests)		Identifies tracks of several other organisms that leave tracks on their cardboard			
	Describes the methods of controlling pests e.g: poison baits, trapping, spraying plants, hunting		Explains the effects to native mammals or plants of leaving pests in the area without monitoring			
4	Summary table presents accurately processed data in a way that makes sense if you read it in context with everything else (e.g. the title may be absent or unclear)		Summary table presents accurately processed data in a way that makes sense in isolation from the rest of the report (e.g. clear titles and months labelled and in a systematic order)			
	Graph shows rat population throughout the year, but may be difficult to interpret e.g. the title may be absent or unclear; there may be errors in the scale on the time axis.		Graphs clearly and accurately shows the rat population throughout the year with no errors that reduce the clarity or accuracy of this information.		Discusses how Maungatautari became an ecological island. (owners agree to allow their property to be fenced, removal of pests, fence to ensure no pests get under, over or through fence, reintroduction of native species, monitoring and continued pest control, funding from council, interested groups).	
	Accurately describes the pattern/s in the rat population throughout the year. This could be that the rat population increases, decreases or stays the same at particular times of the year.		Explains what is likely to have caused the measured pattern in the rat population data throughout the year.		Analyses the potential causes of the patterns observed in the rat population data throughout the year	
	Makes a recommendation to the school that uses collected data.		Makes a recommendation to the school that uses collected data and knowledge of rats.		Makes a well-considered recommendation to the school that uses collected data and knowledge, rats and potential consequences of action OR inaction.	

APPENDIX R

The *Show Home*: Student Work Sheet

SHOW HOME ASSIGNMENT

317 Shadbolt Drive, Leamington, Vuna

DESIGN:

1. Describe the steps involved in the design of this home?

   ____

   ____

2. What are some of the factors that were taken into consideration when designing this home?

   ____

   ____

3. On the house plans provided mark where the sun rises and sets.
4. Which rooms of the home will receive the most sun?

   ____

   ____

5. Is there a prevailing wind that was taken into consideration when the home was being designed?

   ____

   ____

6. Are there any designs that appeal to you (in the books on the kitchen bench or the monitor in the living room) and why?

   ____

   ____

HEAT LOSS AND RETENTION:

1. How is the home heated?

   ____

   ____

2. Where are possible sources where heat is lost in this home?
____

____

3. How is heat loss minimised in this home?
____

____

4. Can you identify ways heat is lost is minimised through:
CONDUCTION:
____

CONVECTION:
____

RADIATION:
____

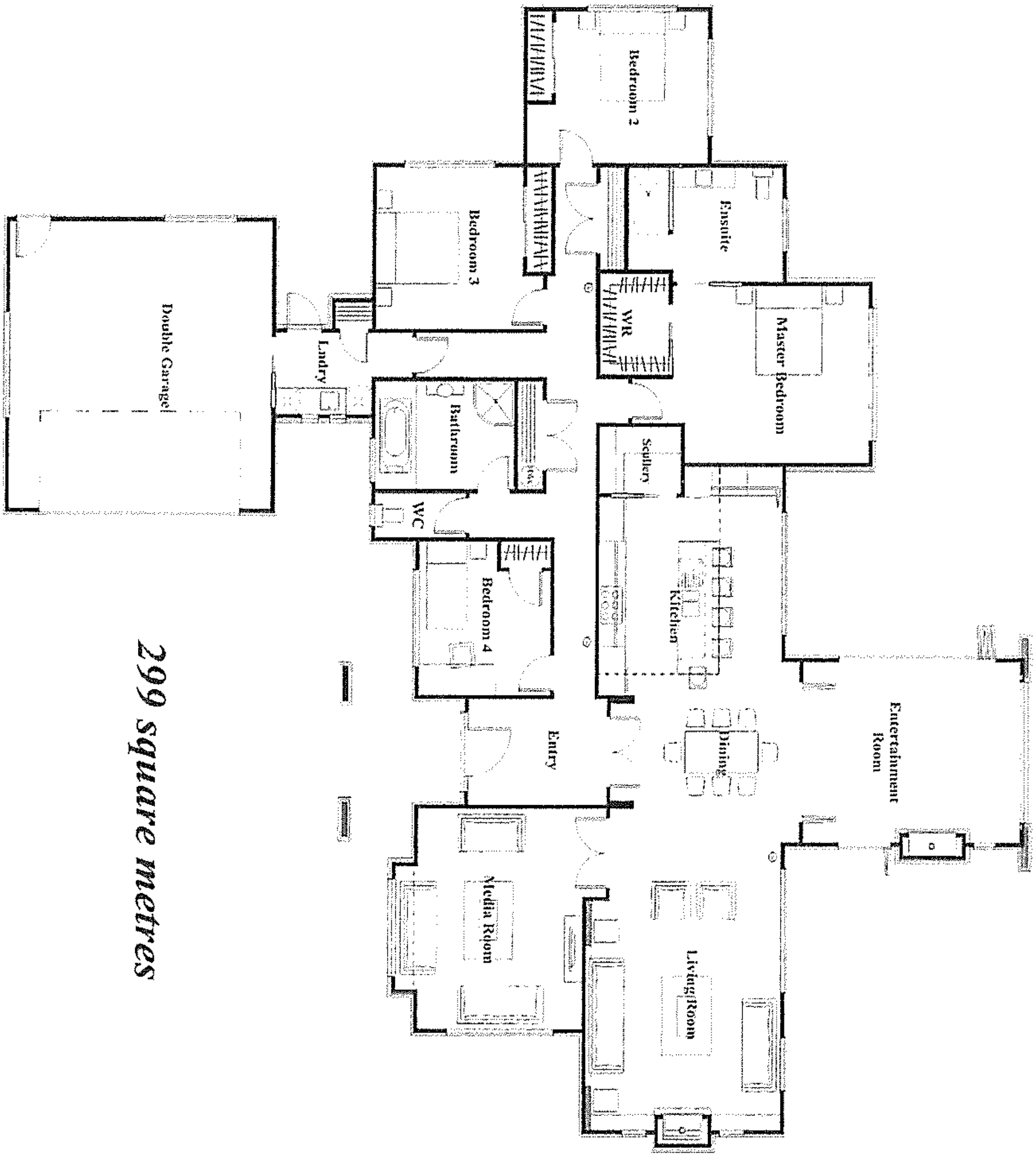
5. Give examples of insulation used in this home.
____

____

Additional notes:

APPENDIX S

A Sample of the Home Designs



APPENDIX T

A Sample of Student Report for AS90943

Grade: N : A : M : (E)

Assessment schedule: Science 90943 The Design Game: Keeping your home warm

Evidence/Judgements for Achievement	Evidence/Judgements for Achievement with Merit	Evidence/Judgements for Achievement with Excellence
Part One: ✓ Questions 1-4 answered. ✓ Questions 5-7 answered. Feasible floor-plan produced that meets the specifications of the design brief (has all the rooms asked for). N/S/E/W marked on plan. **Part Two:** ✓ Questions 8-14 answered. I Report: ✓ • Describes the 3 main heat transfer mechanisms ✓ • Diagram or basic description of why house was designed the way it was (to maximise heat from sun in rooms) ✓ • Statement of which building/insulation materials are the best insulators. ✓ • Describes how to install the insulation with respect to heat retention. ✓ • Describes the implications (keeps heat in, prevents air movements) of the insulating abilities of the chosen house building materials.	**Part One:** ✓ Questions 1-4 answered. Question 7: why different sized windows explained. Workable floor plan produced with all rooms asked for and takes into account building code given (no bathroom off kitchen etc.), size of rooms in proportion to use and scale correct on plan. ✓ Placement of any heating devices shown. **Part Two:** ✓ Questions 8-14 answered. I Report: As for *Achieved*, plus **gives reasons for the way science is involved.** ✓ • Explains how you can reduce the 3 methods of heat loss. • Explains why the floor plan is laid out the way it is. ✓ • Explains why certain materials are better insulators than others. ✓ • Explains R values and how they relate the effectiveness of the material. (peppered thru report) ✓ • Explains how the installation of the insulating materials should be performed based on the evidence data gathered. Estimate of appropriate floor/wall/ceiling thickness of insulation, based on data gathered. ✓ • Explains the structure of the different materials in relation to their ability to be an insulator (air spaces are poor conductors etc.).	**Part One:** ✓ Questions 1-4 answered with respect to why rooms of different sizes. As for Merit ✓ Fully functional floor-plan that takes into account, building code, room size, placement and orientation of rooms with respect to natural heating by sun angle/movement. As for merit. **Part Two:** ✓ Questions 8-14 answered. I Report: As for *Merit*, plus report **links reasons and implications in a way that the science involved is clearly explained.** • As for Merit. sprinkled thru various bits ✓ • Links floor plan to scientific reasoning. Implication of the design/layout of the house to the relative amounts of the three types of heat transfer in the house and how significant each type is. ✓ • Links R value to chosen materials in terms of implication of heat retention. ✓ • Discussion of optimum thicknesses and applications for each type of material. ✓ • Discussion of how each insulation type is affected by condensation or water absorption with science reasons why and how each type of material might be affected. • Relative abilities of each type of insulation to mitigate the effects of winds or air flow.

Justifies choices of materials & gives data to back up evidence.

HEAT LOSS AND RETENTION:

1. How is the home heated?

Heat pumps
Fire place
Underfloor heating

2. Where are possible sources where heat is lost in this home?

Roof
Draughts - Front door, windows
Floor
Chimney - Fire Place

3. How is heat loss minimised in this home?

Insulation → ceiling = Pink Batts
~~Heat~~ electrical heating
Double glazing = Must be everywhere but the garage

8 What external cladding materials offer the best insulation?

Out of the materials I have reasearched, I would chose extruded polystyrene which has an R value of 3.3 at 100mm, as the external cladding I would use. I would use it because it has a high resistance to water and moisture, which will protect the pink batts from water.
My second choice would be aerated concrete which has the R value of 1.43 when it's in a 200mm width. It would require extra insulation becase aerated concrete alone would not have a great enough insulation ability. I also found that brick had the R value of 0.18 in 110mm blocks and weatherboards had the R value of 0.08 in 12mm average pine boards.
Overall, I found that extruded polystyrene and aerated concrete has greater R values and therefore greater insulation ability than most other materials