Understanding Teachers' Perspectives on the Purpose and Importance of Science Education

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ABSTRACT

The focus of this thesis is to identify teachers' perspectives on the purpose and importance of science education. This focus is twofold. It is concerned with finding out what teachers understand the purpose of science education to be, that is, why they believe science is taught in schools and how learning science benefits students in their daily lives. It is also concerned with understanding how important science education is to teachers – how much teachers value science as a learning area, and how this value is reflected within their teaching practice.

This work determines firstly teachers' perceptions of science education practice. It examines how teachers perceive the science planning process; how much involvement and control they feel they have throughout the planning stage, including perceived control over teaching pedagogies and planning material. Simply put, how much do the teachers feel is up to them, and how much do they feel is mandated from management. Secondly, the work focuses on personal perspectives about science education. It seeks to examine teachers' opinions and views on the purpose of science education, why science is taught and what they believe students stand to gain through science education. A major element of understanding teachers' perspectives is to understand what importance teachers place on the teaching of science, specifically the nature of science – what does the nature of science (NoS) mean to them and how do they show this through planning and teaching? NoS is a key element of science education, recognised both internationally and within New Zealand, because it promotes scientifically-literate students. NoS is described as being a critical component of scientific literacy: understanding NoS through scientific practice develops scientific dispositions in students. This study is interested in gaining teachers' understandings of NoS and the importance teachers place on NoS in relation to these global understandings.

The data for this research was collected through interviews with four teachers in two different schools. The study offered the teachers the opportunity to explore their personal perspectives. The findings reveal teachers' understanding of the science curriculum was underdeveloped. The teachers appear to lack understanding of the science curriculum area, including NoS, and this was reflected in their pedagogical approaches and planning. The analysis identified four key themes impacting on teachers' level of understanding: limited science training and professional development, the low status of science education in primary schools, lack of knowledge and experience with current teaching approaches in science, and limited understanding about the purpose of science education. These themes are supported by research demonstrating that they are global and have been acknowledged for many years now. The first theme in this study was identified as the likely root cause of the existence of the other three themes. This finding reveals the nature of teacher training and professional development as a potentially fundamental and critical issue to address in science education. Further research is needed to confirm consistency in these results across New Zealand schools. If consistency is found, this outcome may then raise the issue to one of national importance for science education, demanding attention from government policy-makers, pre-service training institutions and professional development facilitators.

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Introduction and overview

1.1 Introduction

The international call for scientific literacy as a goal of science education in order to sustain a healthy democracy and promote economic and social growth is at an all-time high (Bull, Gilbert, Barwick, Hipkins & Baker, 2010; Milne, 2007; Slavin, Lake, Hanley & Thurston, 2014). Scientific literacy promotes attributes in students and citizens that enable them to relate to and engage in science issues the same way they would with any other area of their lives, such as politics, sports or the arts (Hazen, 2002). These attributes are best developed through the explicit teaching and learning of the nature of science (NoS) i.e., scientific knowledge and practices (Afonso & Gilbert, 2010; Lederman, 2007). Since science is a human endeavour that relates to everyone’s lives many science educators believe a meaningful science education should be accessible to all (Bybee, 2015; Fensham, 2005; Rennie, 2005). Scientific literacy provides a foundation for democratic participation, by equipping students and citizens with the skills be to able gather and sort information, be sceptical and questioning of claims, and use scientific thinking and reasoning when considering issues of a scientific nature that affect themselves, their community and their country (Hipkins, 2012; Ministry of Education (MoE), 2007a). As such, scientific literacy benefits the whole nation as well as the individual.

However, both international and national research indicates that the goal of scientific literacy is not being achieved and NoS skills are generally lacking and considered weak in many students and teachers worldwide (Afonso & Gilbert, 2010; Rennie, 2005; Hipkins, 2012, Hipkins, Bolstad, Baker, Jones, Barker et al., 2002). There is a continuing trend of disengagement in science education resulting in a drop in the number of students studying science world-wide (Fitzgerald, Dawson & Hackling, 2013). The Royal Society (2010) and Tytler, Osborne, Williams, Tytler and Cripps Clark (2008) explain that this disinterest begins at primary level, where many students are becoming disengaged in school science programmes. The National Education Monitoring Project (NEMP) (2008) and the Trends in International Mathematics and Science Study (TIMSS) reports have highlighted this as a major concern for New Zealand (NZ) schools (Bolstad & Hipkins, 2008; Hipkins et al., 2002). Bull et al. (2010) point to the results of the NEMP and TIMSS studies, advising that current practice, resulting in disenchantment with science programmes (Fitzgerald et al., 2013) in NZ schools, is set to continue due to the very limited in-service professional development available.

Monitoring projects would suggest the goal of scientific literacy through the teaching of the NOS is not being achieved by current teaching practice (Bull et al., 2010; Hipkins et al., 2002; Hume & Coll, 2010). It appears from a review of the literature that NZ primary science teaching practice needs strengthening, and could be causing student disengagement with science education beginning in primary school. There is clearly a disparity between the goal and practice of science education. Curiosity over why this disparity exists is the driving force behind this research. The purpose of this research project is discussed below.

1.2 The research purpose

The research presented in this thesis focuses on discovering teachers' perspectives on science education. The study set out to understand what teachers believed to be the purpose of science education, and whether or not they felt science was important to teach in primary school. It also intended to learn about the current pedagogical approaches teachers are using to develop science knowledge and skills in their students and what planning approaches they use. Four teachers from two different schools participated in this study. The teachers participated in in-depth interviews, discussing their perspectives on science education in their schools, their personal beliefs about science, and their understanding of and perspectives on the science learning area of the New Zealand Curriculum (NZC) with a focus on NOS.

The research had two main objectives. The first objective was to explore how teachers teach science by looking into approaches they used to plan science lessons: their perspectives on their involvement and control over science education implementation within their schools; the pedagogical approaches they used in their classrooms; what these teachers felt were important aspects of teaching science; and what they hoped to achieve in science lessons in primary schools.

The second objective of the research was concerned with identifying what teachers understood as the reason for science being taught at primary school i.e., the purpose of science education. This component of the research probed further by asking teachers what they understood the purpose of including NoS within their teaching to be. Why did they feel NoS was included in the NZC and how did they plan for and teach NoS? Finally the study set out to determine what teachers thought about the goal of scientific literacy and what this meant to them.

The project is significant in that it contributes to the field of science education research by examining NZ teachers' understanding of science education. The literature indicates that teachers in the NZ context may not be teaching according to current goals and approaches in science education. It also suggests possible reasons for this mismatch between current NZ policy and practice. This study provides support for these claims as well as creating new understandings as to why there is this mismatch. This research advocates that policy change and requirements are not reaching teachers – and this disconnect is due to a lack of pre-service training and in-service professional development. The research has the potential to contribute to (and implications for) government policy developers, teacher development programmes, and teacher training institutions. NEMP (2008) indicates that quality science education is falling in New Zealand primary schools. It is intended that this project will contribute to developing a better understanding as to why.

1.3 Overview of the thesis

This thesis is organised into six chapters. The literature review in the second chapter provides an overview of the development of science education in New Zealand over the last 40 years, beginning with the science education reforms of the 1980s. The chapter develops an explanation of current international views on the purpose of science education and key aspects of teaching science for the current purpose. Discussion focuses on how international developments in science education have impacted curriculum and policy design in New Zealand, concluding with assertions that teachers in New Zealand (and globally) are implementing their own enacted curriculum, that can result in a mismatch between policy and practice. The chapter concludes with an explanation of how this project is situated within the broader educational literature and an explanation of the purpose and key focus questions of this project.

The methodology of this research is outlined in Chapter 3. An interpretive paradigm was used to frame the research since the goal of the study was to gather teachers' perspectives and understanding of teaching and planning for science education. This chapter also describes the specific methods that were used to gather, analyse and interpret data. A description of the research setting is included, detailing the backgrounds of the schools, the participants (pseudonyms have been used to ensure anonymity), and the researcher. The chapter concludes with considerations of ethical concerns within educational research.

The findings followed by the analysis are presented in Chapter 4. This chapter highlights the aspects of conversations during the interviews that pertain to the key questions as well as to the analysis. The findings are presented as quotations from the data. The analysis is presented according to an inductive approach where themes related to the research questions were identified. Four main themes were identified and these are discussed and explained with reference to the data.

Chapter 5 presents the discussion of the findings. This discussion describes how the findings link with current literature and address the gap in the literature as identified in Chapter 2 i.e., little is known about NZ teachers' perspectives about why they teach science and what is their understanding of the purpose of science education. The discussion aims to explain why and how the themes emerging from the data occur and to determine their underlying cause. The chapter ends with consideration of the implications and limitations of this study.

Chapter 6 summarises the research project and provides concluding comments, including suggestions what further research can and should be commissioned to help close the identified gap in the literature. The study finds that the current mismatch between policy (teaching NoS to achieve the goal of scientific literacy) and practice (teaching according to an enacted curriculum rather than the NZC) may be resolved through improving the pre-service training and in-service professional development in science education for teachers.

Chapter 2
A review of the literature

2.1 Introduction

Chapter 1 provided an overview of this research project, explaining its purpose and aims and provided the context and justification for this research. The chapter concluded with a description of the layout of the research project.

The purpose of this chapter is to explore the development of science education from traditional views of learning to the current reformed science curriculum in New Zealand. The overview will investigate the science education reform movement internationally, highlighting the consensus view of many science educators that the new aim of science education should be to produce scientifically literate citizens. It will then examine the shift towards scientific literacy and a citizenship focus that the New Zealand curriculum document and policy creators have endeavoured to portray in the 1993 and 2007 New Zealand Curriculum policies. The implementation of these 'new' policies in schools leads to further discussion concerning the national curriculum (intended) and the enacted curriculum (taught) found in New Zealand classrooms. The chapter will conclude by highlighting and summarising the research focus, including the key questions addressed in this research.

2.2 The international development of science education

Globalisation and the increasing and rapid development of technology continuously change the way we learn, work and live (Voogt & Pareja Roblin, 2012). In response, curriculum design around the world has had to continuously develop and change to keep pace with the internationalisation of the global economy. Moore (2000) links curriculum reforms in history to significant changes in student population in both size and social composition. These changes in student population can cause existing curriculum content to be considered irrelevant to the new population, which usually results in curriculum reform. Moore explains that when change does occur, it is presented as a solution to a perceived problem, which in this instance is an established curriculum that has been judged inappropriate for certain new conditions. The following section supports Moore's claim, as it describes international shifts in science education and policy due to influences such as an increased population, its changing social composition and advances in technology. It details the international development of science education and curriculum since the 1980s, and discusses the influence this development has had on the design of the New Zealand curriculum.

2.2.1 The traditional view of science education

Science education in schools has traditionally catered to the "recruitment of a scientific elite, and the exclusive focus on canonical science as mental training" (Tytler, 2007, p. 17) and to prepare and select students for university level science and science related careers (Bull et al., 2010). Traditionally science education had a strong focus on content – the ability to memorise and apply the rules and principles of science, and there has been very little focus on the conceptual understanding of how science applies to our lives (Rennie, 2005). This traditional view of science education fails to envision science as a human endeavour; that science relates to everyone in everyday life and should be accessible to all. Instead, it creates a vision of science as only for the elite; only very few are able to understand and relate to scientific phenomena. However, during the late 1970s and early 1980s a reform began that sought to change the way schools taught science (Smith & Gunstone, 2009). Fensham (1992) recognised a proliferation of influences that started the reform of school science curricula, which led to a new vision of science education. These influences are discussed in the followed section.

2.2.2 Science for all

The new vision of science education changed from viewing science as a means of recruiting the elite and moved towards the idea that all students should be able to learn meaningful science since science relates to everyone's lives. Fensham (2005) called for 'Science for All' – an approach to science education that is underpinned by "a belief that meaningful learning of science can be extended to all students and citizens, not just those with interests in science-related careers" (p. 541). In an earlier paper, Fensham (1992) attributed the curriculum reform to many factors, including new research and psychological theories of teaching and learning, new groups of learners, changes in assessment and measurement of learning and new technologies used for learning. Perhaps the most significant factors were newly crowded science classrooms and diverse groups of learners, which brought pressure to reform the science curriculum in two significant ways. Firstly, with larger numbers of students attending science classes it was no longer plausible to believe that all would pursue science as a career. This diversity amongst students rendered the traditional view of science education as a technical discipline for future science professionals obsolete.

Secondly, due to the afore-mentioned new research and psychological learning theories, and the changing composition of the student population, policy writers and educational experts began to see the traditional science curriculum as irrelevant to the needs of the new group of learners, who had significantly different aspirations and preferred learning styles from the students in science classrooms preceding them (Smith & Gunstone, 2009). This change in policy affected the new groups of learners, who until now had been unable to access science education. The Science for All notion was not just that science education should be accessible to all students, but was also focused on the idea that science was to become a public understanding. The focus of school science policy changed from a recruitment of scientific elite to providing a base for the future general public's understanding of science (Fensham, 2005). This change was the first indication of science as a citizens' concern; the recognition that science affected, interacted with and related to the general public in everyday life, and it was important for the general public to understand how. In 1985, Canada, the United States of America, the United Kingdom and the United Nations Educational, Scientific and Cultural Organisation (UNESCO) committed to Science for All, beginning the change in science education in the western world (Fensham, 2005). However, regardless of the policy changes, the resulting curriculum content and dispositions towards teaching appears to be still reflecting the traditional view of science (Rennie, 2005). Although the notion of Science for All was established in 1985, Rennie notes that in 2005 the traditional approach to teaching science was still evident in most classrooms. Four years later, Smith and Gunstone (2009) concurred with Rennie, expressing the view that teachers are failing both the future scientist and the future citizen with the continued traditional view of teaching science. Slavin et al. (2014) add that even in 2014, despite international curriculum goals advocating scientific literacy and student inquiry, these approaches are still not commonplace in classrooms. Traditional teaching approaches continue to dominate teaching practice. It is because of these practices that there has been a call for a 'new vision' of Science for All, which has resulted in the notion of scientific literacy with explicit focus on the teaching and understanding of the Nature of Science (NoS).

2.2.3 Scientific literacy and nature of science

The new focus of science education in curriculum reform started a shift from teaching science in order to recruit scientists, to teaching science to all students so that they may possess an understanding of how science relates to them and their lives. Scientific literacy goes further than looking at the individual, but rather at how the individual will participate as a current and future citizen with respect to social and scientific concerns that affect them and their community (Hipkins, 2012). NoS, as described by McComas, Clough and Almazroa (2002), includes elements such as the history, sociology and philosophy of science and is concerned with developing a background to science, rather than focusing on scientific content. Lederman (2007) builds on McComas et al.'s description by adding that NoS refers to the epistemology of science, i.e., science as a way of thinking, investigating and knowing. It is also concerned with the values and beliefs inherent to scientific knowledge. Capps and Crawford (2012) also stress the value of developing an understanding of the nature of scientific inquiry as a key aspect to NoS. Scientific knowledge is generated through scientific practices. Students develop knowledge about the nature of scientific inquiry through inquiry based approaches to teaching NoS and scientific concepts. The development of understanding about NoS promotes scientifically literate students and NoS is often described as being a critical component of scientific literacy (Lederman, 2007). Scientific literacy, through an understanding of the NoS, aims to engage students and provide equitable opportunities for students to understand how science affects their lives and how it explains natural events in order to "provide a foundation for democratic participation and for sound personal decision-making" (Hipkins, 2012, p. 5).

Although scientific literacy appears to be a simple term, researchers have found that it is not well understood, possibly because it seems to be lacking one single definition (Bybee, 2015; Goodrum, Hackling & Rennie, 2001; Holbrook, 2012). While there are many different variations on what scientific literacy means, they all imply an application of scientific knowledge to everyday situations that individuals will encounter as citizens – applying scientific methods to social, economic and personal issues; and developing an appreciation of science as a human endeavour and intellectual achievement (Bybee, 2015; Goodrum et al., 2001; Hurd, 1958; *Rennie, 2005*). One definition of scientific literacy given by Goodrum et al. (2001) is as a way of thinking and engaging with science in everyday life; not about knowing science as a body of knowledge but rather knowing science as a way of thinking, finding, organising and using information to make decisions. Rennie (2005) expands on this definition, explaining what a scientifically literate person looks like:

> *Scientifically literate people: are interested in the world around them; engage in the discourses of and about science; are able to identify questions, investigate and draw evidence-based conclusions; are skeptical and questioning of claims made by others about scientific matters; make informed decisions about the environment and their own health and wellbeing (p.11).*

The ability to apply scientific knowledge to everyday situations is becoming more and more critical if people are to participate fully in modern society. Hazen (2002) describes perhaps a more simple view of what scientific literacy looks like. He describes scientifically literate people as those who can engage with science articles in the media with the same ease as they would with sports, politics or the arts. As citizens we are asked to form opinions and sometimes participate in social action regarding scientific issues. In order for us to do this, we must be able to apply the above behaviours to every situation. It is crucial that all students develop these behaviours in order to be able to participate in this way in their communities. Danni (2009) views scientific literacy as an outcome of NoS understandings and practices by explaining that a person who is scientifically literate understands the nature, history and processes of science. They are able to recognise the inter-relationship of science, technology and society.

Thus scientific literacy is about engaging with science in a meaningful way through the context of everyday life and issues that will occur/are occurring/have occurred for the students (Hazen, 2002). It is not about knowing science as a body of knowledge, or memorising science as a list of facts or procedures, but rather recognising that the platform to which this ‘body of knowledge’ is applied has and is continuing to change. “We are living in a world where science itself must adapt and thus we ourselves, especially teachers and educators of the discipline, must immediately recognise that we are not teaching a static discipline” (McFarlane, 2013, p. 35). McFarlane explains that we are not teaching science for an understanding within the classroom boundaries (content), but rather we should be creating opportunities in the classroom for students to have responsibility for their own learning and self-experiences that relate to the world around them (context) – “a borderless classroom called the global environment” (McFarlane, 2013, p. 35). Scientific literacy has a strong citizenship focus, meaning that being scientifically literate is not only beneficial for the individual, but also for the community. If all citizens have at least some understanding of scientific reasoning and thinking skills then they can all contribute and participate as informed citizens on issues that concern themselves, their community and their country. A scientifically-literate population is essential to sustain a healthy democracy and contribute to the future economic and social development of the country (Bull et al., 2010).

The demand for education to facilitate scientific literacy has emphasised the development of understanding about NoS (Afonso & Gilbert, 2010); learning about the nature of science including scientific practices, is a means by which students can become scientifically literate and has become a critical educational outcome worldwide (Lederman, 2007). McComas et al. (2002) characterise NoS as a blend of various social studies of science including the history, sociology and philosophy of science. This blend is combined with research from the cognitive sciences (such as psychology) and results in “a rich description of what science is, how it works, how scientists operate as a social group and how society itself both directs and reacts to scientific endeavours” (p. 4). NoS is not directly concerned with explaining the natural world, the way science itself is, but rather it explains science in all its aspects. Students need an understanding of ‘the background’ of science in order to understand how science is connected with the world. Not just in a way that explains everyday phenomena, but how science is also social, historical, philosophical and psychological. Afonso and Gilbert (2010) advocate that many studies have shown that NoS practices and attributes are more successfully acquired with explicit focus and approaches. When NoS is explicitly focused on and taught, students are provided with opportunities to see and understand how science knowledge has changed and developed over time and how scientists work, question, experiment, communicate, gather evidence, sort information, and use scientific thinking and reasoning when considering social and personal issues and decisions (MoE, 2007a). Students get to see how scientists participate in and contribute to their communities and to wider global issues. When NoS principles are taught through exploration of specific scientific concepts (contexts), students are also explicitly learning key science concepts (Bull et al., 2010). Acquiring this understanding is the purpose of science education – to provide students with significant knowledge and ways of thinking about the world around them, which enables them to become informed citizens – capable of making decisions about and participating effectively in science-related issues that affect all our lives (Milne, 2007).

The overwhelming consensus from international literature is that the overarching purpose of science education is to produce scientifically literate students who can participate in society (Hume, 2009). New Zealand's science curriculum has been understandably affected by the international research in this area, such that New Zealand researchers and educational professionals now view the purpose of science education to be the acquisition of scientific literacy by students (Milne, 2007).

The 1993 New Zealand Curriculum (NZC) showed potential for the development of scientific literacy and even had a focus on NoS. However, it seemed to fall short in its ability to unify NoS with the other science strands (Hipkins & Barker, 2002, as cited in Barker, 2004). The reasons for this shortfall are discussed in the next section.

2.3 The influence of the development of international science education on New Zealand curriculum design.

The above section explained the purpose of learning about the NoS and the importance of scientific literacy from an international perspective. The following section will illustrate the effect the international research and science education development has had on New Zealand curriculum design. The 1993 NZC development was the result of extensive reviews of international curriculum and assessment policies in the 1980s (Aikin, 1995). The 1993 curriculum was reviewed to include the notion of science for all and consideration of the NoS. However, it has been suggested that due to lack of specific direction, the intentions of the curriculum were misinterpreted (Hipkins, 2012), and as such the 1993 NZC failed to meet its goals (Bell, Jones & Carr, 1995; Hipkins & Barker 2002, as cited in Barker, 2004). Research suggests resistance to embracing the 'new curriculum' was due to teachers' fear that they would lose their philosophy and culture (Aikin, 1995). This outcome produced the need for further research in curriculum design and the 2007 NZC was produced in consultation with over 15,000 students, teachers, principals, advisors and academics (MoE, 2007b). The science learning area in the 2007 NZC has a clear focus on NoS that has been explicitly identified as the overarching strand unifying all science strands.

2.3.1 The 1993 New Zealand science curriculum

Following the science reform of the 1980s, the New Zealand science curriculum developed in 1993 aimed to support the new science education approach of 'science for all' (Ryan, 2011). It sought to include and provide a meaningful and formal science education for all students, regardless of gender, race and ethnicity, differing abilities, disabilities and career intentions (MoE, 1993). While the 1993 NZC claimed to have reformed from traditional curriculum policy views, Aikin (1995) makes the point that of the seven different learning areas in the 1993 NZC, three continued to be expressed in the traditional curriculum view i.e., subject-based Mathematics, Science and Technology. These subjects were designed to stand alone, with little allowance for being integrated with other curriculum areas. In contrast, the other learning areas were designed to promote the apparent established teaching practice of integrating learning areas as seen throughout New Zealand primary schools. This difference shows that while it was policy that meaningful science education was to be extended to all students, in practice, perhaps as a result of interpretation by curriculum implementers (teachers and schools), the content and style of the science curriculum document remained very much traditionally focused (Hipkins, 2012). Donn and Bernie (1992, as cited in Aikin, 1995) support this contention by identifying that primary teachers felt that much of the draft for the 1993 curriculum reflected what they were already doing in their classrooms and as such they did not need to change teaching practices. For example, in the 1992 Donn and Bernie study many teachers felt that the intention of the curriculum was to encourage more open investigation, and to allow students to experience 'how scientists work' could be achieved through current teaching practice, by allowing for more investigations within their teaching, rather than changing how they taught scientific inquiry (Hipkins, 2012). This finding appeared to reinforce a practice of teaching 'a single scientific method' for a lot of teachers, thus confirming many teachers' opinions that they were already 'doing' the requirements of the new framework and supporting the impression that existing It appears that teachers were not prepared to change their teaching practices to meet a new framework for teaching, but rather sought ways to incorporate the new requirements into their existing practice. In effect, the notion of 'science for all' was incorporated into the traditional 'future scientist' classrooms.

Developing scientific skills and attitudes were presented in the 1993 science curriculum document separately from NoS and the other science strands (MoE, 1993). Hipkins (2012) identifies NoS as a new strand in the 1993 NZC that was introduced under the heading "Making Sense of the Nature of Science and its Relationship to Technology" (MoE, 1993, p. 24). This presented NoS as specifically relating to technology and separate from the other science strands. Hipkins (2012) describes the use of a 'weaving' metaphor to explain how the NoS strand would work with the other science strands including the development of skills and attitudes. However, because of its (NoS) affiliation with technology many teachers did not see it as a science strand (Hipkins, 2012). Hipkins criticises the specific lack of direction about what this new interweaving of NoS throughout the other science strands might look like or the specific purpose it might serve. Due to the lack of direction about NoS, coupled with the misinterpretation of NoS as a technology strand, some teachers saw the technology curriculum document as a replacement for NoS and assumed NoS had lost its relevance and could be safely ignored. The 1993 curriculum stated that it was concerned with creating a science education that was inclusive, considered impacts of science and technology upon the Earth and those who exist on it, and fostered responsible decision-making about scientific issues (MoE, 1993). There was potential within this document for the teaching of NoS aimed at scientific literacy, however, these important terms were not explicitly described and there was a lack of direction regarding what the changes would look like or their purpose. Hipkins (2012) claims that there is evidence to show that the introduction of NoS did not prompt any curriculum change. In response to these acknowledged challenges, the government provided professional development in the form of a website called Science IS (Hipkins, 2012). The website was designed with the intention of explaining NoS and providing examples of traditional learning activities refocused to include NoS. However, Hipkins explains that it was not made clear how and why NoS could change learning outcomes and due to the webpage layout and teachers' interpretation of the content, NoS was once again misinterpreted and its good intentions became subverted in practice. As a result it has been observed that many teachers made no real effort to embrace the new framework, but rather sought ways to incorporate the new requirements into pre-existing practice (Donn & Bernie, 1992, as cited in Aikin 1995; Hipkins, 2012). Perhaps these omissions are why it is claimed that this document fell short of its goals (Bell, Jones & Carr, 1995; Hipkins & Barker, 2002 as cited in Barker, 2004).

2.3.2 The 2007 New Zealand science curriculum

During a review of students' engagement and achievement in science education from 1995-2007, two major assessment projects, the National Education Monitoring Project (NEMP) and the Third International Mathematics and Science Studies (TIMSS), were undertaken in New Zealand. These two projects were designed to assess NZ students' achievement in science, and the results indicated areas of student underachievement and disengagement in science, particularly as the students got older (Bolstad & Hipkins, 2008; Bull et al., 2010). These results, combined with the international call for scientifically literate citizens in all societies, contributed to another attempt at creating a science curriculum where an understanding of NoS and inquiry-based learning were important components (Hume, 2009). According to Bull et al. (2010), the 2007 science curriculum was developed with four main purposes:

1. Preparing students for a career in science (Pre-professional training).
2. Equipping students with practical knowledge of how things work (Utilitarian purpose).
3. Building students' science literacy to enable informed participation in science-related debates and issues (Democratic/citizenship purpose).
4. Developing students' skills in scientific thinking and their knowledge of science as part of their intellectual enculturation (Cultural and intellectual purpose) (p. 7).

The teaching of NoS supports all four of these purposes (Bull et al., 2010; MoE, 2007) in that:

1. Understanding NoS provides students with fundamental knowledge about how science and scientists work, thus preparing those interested for a career in science.
2. Investigating NoS provides opportunities for students to explore everyday phenomena and equips them with practical knowledge about how the world around them works.
3. Exploring NoS examines ethical issues in science and allows for students to explore how scientists debate and provide evidence to support claims, developing scientific literacy in students.
4. Engaging in NoS develops scientific thinking skills and knowledge that can be applied to cultures and communities, increasing students' intellectual enculturation.

As presented, NoS is an integral part of the 2007 NZC, which is why it is presented within the curriculum as an overarching strand. The other four strands are intended to serve as contexts for the teaching of NoS (Bull et al., 2010). One noteworthy difference between the 1993 and 2007 curriculum is the layout of the 2007 NZC. The science section is more succinct in the sense that all strands are presented on one page (per level) with NoS at the top (MoE, 2007). This format shows a more clearly defined link between the strands and the overarching integration of NoS.

The 2007 NZC specifically included NoS as a core strand in science. In the science overview it explains what students will be able to learn through NoS. However, there is no clear explanation of what NoS is. The statement simply explains NoS as "the overarching, unifying strand" (MoE, 2007, p. 28). It gives no summary of its characteristics such as described by McCommas et al. (2002) in section 2.2.3, rather it presents a list of skills and knowledge students will develop. It does not provide a detailed explanation about how students will develop the skills described, except to say that these outcomes will be "pursued" through the other context (strands) (MoE, 2007a, p. 28). The pursuing of NoS outcomes is left open to interpretation and implementation by teachers. Similarly there is no mention of the term 'scientific literacy'. However, Hume (2015) maintains that at the heart of the science learning area lies the goal of scientific literacy. She explains that although the term 'scientific literacy' is not specifically mentioned, "the curriculum statement strongly promotes the development of attributes in students that reflect those of a scientifically literate citizen" (p.5). Those who are familiar with scientific literacy recognise this goal within the curriculum document and understand that it is through the teaching of NoS that scientific literacy is ultimately achieved. However, as many researchers agree, scientific literacy is not well understood (Bybee, 2015; Goodrum, et al., 2001; Holbrook, 2012). It is understandable then, that those who have not experienced specific training or professional development regarding the term may be less clear on the purpose of the NZC. Hipkins and Barker (2002, as cited in Barker, 2004) have made it clear that curriculum development in the absence of teacher professional development is likely to have very little impact. Barker (2004) affirms this view by explaining that devising curriculum aims without simultaneously developing innovative pedagogies is bound to fail. Bull et al. (2010) report that, sadly, this is the case in New Zealand. There has been very little support or in-service professional development in science teaching for many years. Evidence suggests that primary-trained teachers in New Zealand have low levels of pre-service training in science education and they receive little on-going professional development, which contributes to their low levels of self-efficacy about their ability to teach science (Bull, et al., 2010; Gluckman, 2011). These findings correspond with global concerns (Slavin, et al., 2014).

In recognition of this lack of professional development around curriculum policy implementation, the New Zealand Ministry of Education (MoE, 2015a) has explicitly promoted the idea of developing citizenship capabilities as a way of promoting scientific literacy. This promotion highlights the New Zealand government's recognition of the importance of enabling students to be scientifically capable and engaged with science. The development of citizenship capabilities supports the teaching of NoS for scientific literacy in an explicit way, providing accompanying resources to support teaching and learning. Scientific dispositions are considered important in developing scientifically literate citizens (Rennie, 2005), because such dispositions make students ready, willing and able to use their science knowledge (MoE, 2015a). The Ministry of Education has identified five science capabilities to help develop such dispositions. Students will be able to: gather and interpret data, use evidence, critique evidence, interpret representations and engage with science (MoE, 2015b). These science capabilities help students practice the type of thinking and actions needed to become informed citizens.

2.4 The two conflicting curriculums of New Zealand

Researchers have identified two curricula currently in play in New Zealand schools i.e., the mandated curriculum – the 2007 NZC, and the enacted curriculum – what teachers are actually teaching (Hipkins, et al., 2002; Hume & Coll, 2010; Jones & Baker, 2005). Despite the intentions of the NZC and policy changes in science education, there is a mismatch between these two curricula because teachers are continuing to teach according to traditional approaches (Saunders & Rennie, 2013). Possible reasons for the lack of change are discussed below.

Researchers believe this adherence to tradition is because teachers were exposed to this style of learning themselves, and so their existing skills and professional identities are orientated towards a traditional curriculum (Bull, et al., 2010; Irwin, 2000; Jones & Carter, 2007). This lack of pedagogical change means the content and the way science is being taught is remarkably similar to that provided for (earlier) future scientists. Smith and Gunstone (2009) explain that just as teachers use their existing skills, they also use existing traditional resources such as text-books and scientist-provided explanations of scientific concepts. These explanations are often very technical and overly complicated, especially for the future citizen. Slavin et al. (2014) explain that contributing to teachers' orientation towards traditional approaches (what they know) is teachers' underdeveloped science content knowledge and low self-efficacy. Teachers with such orientations continue to simply reiterate explanations rather than explaining science concepts in a way that relates to and connects with the learner. Their low levels of self-efficacy and confidence in science teaching, mean these teachers can become unwilling to take risks or deviate from what they know and so they continue to teach from a traditional approach (Slavin, et al., 2014). Low levels of confidence can even cause some teachers to avoid teaching science at all (Tytler, et al., 2008).

An additional reason for this mismatch between the mandated curriculum and teaching practice appears to be a lack of professional development or low levels of pre-service training in NoS, which is resulting in apparent reluctance to include NoS in teaching practice. The results of recent NEMP and TIMSS projects showed low levels of achievement and understanding of NoS, indicating that teachers were perhaps not teaching the intended curriculum (Hipkins, et al., 2002; Hipkins & Bolstad, 2008). Gilbert (2012) supports these findings by explaining that while NoS is an important part of the science curriculum, and is essential to students' understanding and experiencing "what it [science] is, how it is done, and importantly, the skills and knowledge it takes to be successful in it – it is not evident in school science" (p.6). Afonso and Gilbert (2010) in their research report on assessing nature of science in pseudo-science contexts claim that internationally there have been many studies that show a widespread weakness of understanding of NoS by students and both pre-service and in-service teachers in the last 40 years. Perhaps in accordance with this weakness, Hipkins (2012) explains that typically teachers' own education in science did not include a NoS component. This omission means that teachers have to make a specific and concerted effort to learn a new type of content and also they need to change their way of thinking about teaching and learning in science, both of which, Hipkins adds, can be formidable challenges for busy teachers. Afonso and Gilbert's and Hipkins' claim that teachers' understanding of

NoS is underdeveloped, either through teachers' inadequate pre-service education or the challenges in obtaining professional development to support changes in practice and beliefs, leads to teachers' apparent reluctance to include NoS in their practice. Hume and Coll (2010) claim that the practices of secondary teachers actually run counter to the aims of the curriculum. Students are not experiencing science in an authentic way, which is limiting their ability to understand NoS. Students are often subjected to difficult science concepts that are unrelated to their everyday life, with uninspiring practical work that does not authentically reflect the true nature of science or how scientists work. These practices result in students experiencing a science education that is far removed from 'real science' (Fitzgerald, et al., 2013; The Royal Society, 2010).

Another reason the existing enacted curriculum fails to match the intended curriculum is that schools and teachers, and even government policy, place a low status of importance on science education. Research suggests that time set for planning and teaching science is continuing to diminish as priority is given to other subjects, specifically those being tested for national accountability purposes (Slavin, et al., 2014). Since the publication of the NZC, further educational policies have been introduced that are undermining the achievement of the scientific literacy goals in the curriculum (Hume, 2015). The National Administration Guidelines (NAGS) (MoE, 2015c) dictate that all schools should develop curriculum policies that allow all students opportunities to achieve in all curriculum areas. However, the policy specifically states that priority be given to achievement in literacy and numeracy, especially in years 1-8. Considering that national educational policy is stipulating that literacy and numeracy have priority over other learning areas including science, it is understandable that schools and teachers assign a low status to science education. Bolstad and Hipkins (2008) explain that as a result of this policy, many schools appear to be developing policies of learning that emphasise literacy and numeracy and integrating knowledge from other curriculum learning areas such as science. Since learning in literacy and mathematics is now being monitored through standards, Slavin et al. (2014) explain that teachers will naturally assign more importance to these areas in terms of time and resources than areas that are not monitored through standards. Due to NAGS standard policy, teachers are under pressure to perform in these subject areas. This pressure naturally places a low status on other subject areas such as science, supporting Hipkins' (2012) claim that obtaining professional development in science is a formidable challenge for busy teachers. As Slavin et al. (2014) explain, teachers are going to assign their time and resources to learning areas that have more importance, not on gaining professional development in areas that are seen as of low importance. The NZC policy is being undermined by new educational policy (Hume, 2015) which is causing a major difference between the mandated curriculum and teaching practice.

Researchers have provided a variety of reasons for teachers continuing to teach to an outdated system and why they are apparently reluctant to embrace the current purpose of science education. One possible reason could be the lack of professional development accompanying the 1993 curriculum document, both for in-service teachers and those who were in training. Though some professional development may be available for teachers now, it is not mandatory (B. Ryan, personal communication, February 13, 2016). Due to the NAGS pressure and the corresponding status placed upon certain subject areas, possibly only those teachers with a clear interest or ambition in science would be disposed to seek professional development (Hipkins, 2012; Slavin, et al., 2014), limiting the number of teachers who truly understand what they are teaching and why. The likelihood that NZ primary teachers have not received clarification or education about NoS and scientific literacy is the basis of my thesis, which is discussed in the next section.

2.5 Research focus and key questions

The focus of this research is to discover whether NZ teachers are aware of the implicit goal of scientific literacy in the NZC and the importance of students' understanding of the NoS in achieving that goal. Considering that the purpose of science education has continued to change and develop, particularly over the past few decades, and the apparent lack of teaching development accompanying the new curriculum, it is very possible that teachers are unaware of current thinking about the purposes of science education. While conducting research into science teaching practices and purposes is a positive endeavour, it fails to serve any purpose if the research is not shared with those whom it concerns (in-service teachers) (Menter, et al., 2011). It is this researcher's belief that before potential issues of time restraints, work-loads or pedagogical knowledge, etc. can be addressed, it is necessary to ascertain if teachers understand the purpose of science education. If teachers are unaware of the need for scientific literacy, then it is unrealistic for researchers, experts and even curriculum developers to expect teachers to teach for this purpose. Teachers' understanding of the purpose of teaching NoS (developing scientific literacy) and their commitment to teaching NoS also need to be determined. If teachers have not received instruction regarding the importance of NoS or professional development about how to teach NoS through the other strands of science, then it is unrealistic to expect NoS to be taught or students to gain an authentic experience of NoS. If teachers are aware of NoS and the importance of teaching it, then further research may be considered to examine why there appears to be an enacted curriculum that differs from the mandated curriculum, and why we are not producing scientifically literate students (Bull, et al., 2010).

There are four key questions this research addressed:

1. What do current New Zealand primary teachers believe to be the purpose(s) of science education?
2. What understanding do current New Zealand primary teachers have about scientific literacy and what place do they think it has in science education?
3. What does the Nature of Science mean to current primary teachers, and what do they believe is the purpose of teaching NoS?
4. How do current primary teachers include NoS into their planning and teaching?

The answers to these four questions should provide insight into teachers' current understanding of science education and the factors influencing their ability to teach for the purpose of developing scientifically literate students.

2.6 Chapter summary

This chapter has outlined the changing purpose of science education from the 1980s to the present day, with particular focus on the New Zealand context. The traditional purpose of science education was seen as a recruitment of a scientific elite (Tytler, 2007) – those who would pursue science-related careers. This purpose changed during the 1980s due to a number of influences, which resulted in the notion of 'science for all' (Fensham, 1992).

However 'science for all' seemed to fall short of its ambitions and even though all students were able to study science, it was still taught in a very traditional way, with the result that not all students had access to a meaningful science education (Rennie, 2005). The notion of 'science for all' was replaced by the need for scientific literacy for all, which quickly became an international goal of science education.

There are several reasons why scientific literacy has become the international goal of science education. One key reason is that student development in scientific thinking and reasoning, and over-all understanding of the nature of science, helps develop the intellectual properties and, therefore, dispositions of the students (Bull, et al., 2010). Another is linked to the benefit for communities and the country. Scientific literacy has a huge effect on citizenship. It promotes participation in and contribution to socio-cultural and scientific issues in a meaningful and informed way (Hipkins, 2012). Developing scientifically literate citizens promotes future economic and social development and is essential to sustain a healthy democracy (Bull, et al., 2010).

If scientific literacy is to be achieved, then teachers must be teaching with explicit focus on NoS, because only through an understanding of NoS can students gain an authentic and real understanding of what science is and what it means to 'do' science (Gilbert, 2012; Hume & Coll, 2010). Understanding NoS helps students develop a 'background' knowledge of science. This knowledge contributes to their ability to participate as informed, scientifically literate citizens in future socio-cultural and scientific issues.

Curriculum developers in New Zealand have implied scientific literacy as a goal in both the 1993 and 2007 curriculums. However, it can be argued that both curricula have fallen short of achieving this goal for various reasons. The 1993 curriculum's seeming lack of direction may have contributed to the continuation of traditional teaching approaches and content (Hipkins, 2012) and while education policy intended to embrace science for all, in reality students were simply allowed into classrooms designed for the future elite scientists (Aikin, 1995). It is not surprising, therefore, that monitoring projects show a significant correlation between students' limited exposure to NoS and a decline in student achievement and engagement in science education (NEMP, 2008).

The 2007 NZC was developed with a more explicit NoS component, and an intention that NoS would be taught through the science strands (Bull, et al., 2010; MoE, 2007). The 2007 NZC defines four main reasons for studying science, all of which can be achieved through teaching NoS. However, while NoS has been acknowledged as the overarching, unifying strand, there is little detail about what NoS actually is and why it is important. Because of the limited explanation provided, responsibility is now on the teachers to find out for themselves the value of NoS and how to teach it, which Hipkins (2012) advises could possibly reduce the motivation for teachers to teach it.

Researchers have discovered a mismatch between the mandated curriculum and the enacted curriculum within NZ. They attribute this mismatch to three significant reasons. One, teachers' skills and professional identities are orientated towards traditional approaches to teaching due to low levels of efficacy and personal experience. These orientations towards teaching science are causing a mismatch between the intentional practices of the curriculum and actual classroom practice. Two, teachers appear to be lacking professional development or training around the purpose of NoS, its importance, and how to include it in their practice. Thus teachers are not teaching according to the curriculum intentions or content. Three, due to recent educational policy expressed in the NAGS, it has been discovered that teachers are not teaching according to the original curriculum policy. Instead, because of standards and monitoring of certain subjects, teachers are assigning low importance to science education. The result is that teachers are assigning more time and resources to areas that are being monitored, and areas such as science are becoming integrated within other learning areas. Teachers are ignoring the policy of the science NZC and enacting their own curriculum to include teaching science while complying with the requirement to focus more on the monitored areas.

The current situation of teachers enacting their own science curriculum in New Zealand schools has led to this research. The underlying question is – what do teachers believe to be the purpose of science education and what is the importance of NoS? The next chapter will explain the methodology used to guide the research.

Chapter 3
Research methodology

3.1 Introduction

The previous chapter explored literature and research regarding science education in New Zealand and around the world. It traced developments in science education since the 1980s and how these developments have resulted in current goals and purposes. The development of the New Zealand curriculum over the last few decades has now cultivated a focus on NoS for the development of scientifically literate future citizens (Hume, 2015; Lederman, 2007; Slavin et al., 2014). The previous chapter also highlighted an apparent mismatch between the intentions of the science learning area within the NZC in regards to purpose and critical aspects to science education – NoS – and teachers' understanding and practice within science. Research suggests that teachers are not incorporating NoS in their teaching and so are not teaching to fulfil the purpose of science education. Instead teachers are continuing to teach using an outdated system and retain an outdated view of the purpose of science education (Irwin, 2000;

Smith & Gunstone, 2009; Tytler, 2007). To gain a clearer insight as to why there appears to be an enacted curriculum, this study believes there is a need to first ascertain if teachers are even aware of the current purpose of science education. That is how this study adds to the other research in this area. It will endeavour to understand what teachers believe to be the purpose of science education and will investigate how their beliefs are reflected in their teaching and planning practice.

Chapter 3 aims to explain the research methodology used to guide this research. Research methodology is the overall picture of the research design, from the starting point of developing a research question through to the analysis and discussion of the findings. The methodology describes the philosophical framework that underpins the development of the research process (Lather, 1992). The methodology is not only concerned with what was done, but also why it was done. It explains why the research is important and gives justification for the approaches chosen (Rangahau, 2016). Cohen, Manion and Morrison (2007) explain the difference between methods and methodology. Methods are the approaches to gathering and analysing data. Methodology is the whole process – guiding the researcher in choice of paradigms, types of data, methods, and analysis techniques.

The methodology that guided this study invoked the perspective of an interpretive paradigm because this study wanted to understand teachers' beliefs and perspectives. As this study was interested in gathering an in-depth understanding of teachers' perspectives, and due to the small scale of the research, qualitative data was sought rather than quantitative. Section 3.2 of this chapter will discuss the interpretive paradigm and qualitative data and their suitability to this study. Semi-structured interviews were considered the most appropriate data-gathering method for the purpose of this study due to their qualitative nature (Fontana & Frey, 2000). This is discussed in further detail in section 3.3. The context for the research is established in section 3.4, which highlights the research settings, introduces the participants and provides background information on the researcher. Thematic analysis is an approach often used to interpret qualitative data and lends itself nicely to the analysis of this research data. Section 3.5 provides an explanation of thematic analysis and a description of its appropriateness for this research. Finally this chapter will conclude with consideration of ethical concerns and how they were mitigated within this research.

3.2 Interpretive paradigm

Educational research concerns itself with contributing and adjudicating new knowledge. These tasks are done through a systematic approach with the goal of sharing findings with other practitioners to improve and gain understanding about educational practice (Menter, Elliot, Hulme, Lewin & Lowden 2011). How we conduct the research depends on the purpose of the research – what we want to know and why. The purpose of the research will determine the design methodology and paradigm used; “fitness for purpose must be the guiding principle: different research paradigms for different research purposes” (Cohen, Manion & Morrison, 2011, p. 1).

Donmoyer (2006) provides a commonly used definition of a paradigm, derived from Thomas Kuhn, as the underlying assumptions and intellectual structure upon which research and development in a field of inquiry is based. Patton (1990) explains it as a world view or general perspective; a shared understanding of reality. Markula and Silk (2011) combine these two explanations and expand on them by describing what paradigms do and their role in educational research.

> *Paradigms provide the orientations towards how researchers see the world (ontology) and the various judgements about knowledge and how to gain it (epistemology). Together ontological and epistemological assumptions form philosophical parameters that guide decisions on appropriate methodological practices that will allow the investigation of particular instances of physical culture. In this regard, paradigms guide all aspects of undertaking research – questions asked, ethical stances, research actions, methods choices, relationships to participants, judgement of the quality of the research.* (p. 24)

One example of a paradigm is the interpretive paradigm. The interpretive paradigm is characterised by its concern for the individual and wanting to understand the subjective world of human experiences (Cohen, Manion & Morrison, 2007). Researchers working under this paradigm are concerned with capturing how actors (participants) make sense of their sociocultural contexts and activities (Borko, Liston & Whitcomb, 2007). Borko et al. advise that interpretive research within education can be used to address improvement of practice and inform policy and programme design.

The interpretive paradigm was chosen to guide this research. The focus of this study was to understand teachers' perspectives about how they perceived their involvement in teaching and planning science and what they perceived to be the purpose and importance of science education. This study also had the potential, depending on the findings, to address any issues that arose around teaching practice or policy design. Research under an interpretive paradigm is most likely to produce qualitative data because qualitative data consists of words and descriptions (rather than numbers like quantitative) (Trochim, 2008). This small-scale study was interested in specific, contextual, and descriptive data from a small group of participants and so the data collected was considered qualitative (Thomas & Harden, 2008).

This paradigm and data type were chosen because they best matched the nature of this research. There are some concerns by researchers that because of the subjective nature of this type of data, reports can be incomplete or misleading and are unique to the settings or contexts (Johnson & Onwuegbuzie, 2004). This type of data and research is not generated to be used as a generalization or applied to other settings. Readers and researchers must be aware that the findings are specific to this study and provide a report accurate at the time of the research.

The following section will describe the method of data gathering used in this study. Semi-structured interviews were deemed the most appropriate method because of their ability to create an open dialogue of conversation between participant and researcher, developing insight into the participants' perspectives and beliefs.

3.3 Semi-structured interviews

Menter et al. (2011) explain how interviews gather qualitative data by opening a dialogue aimed at eliciting information on people's perceptions, attitude and meanings. Cohen et al. (2011) expand on this explanation by adding that interviews are more than just a dialogue, they are a flexible tool for data collection, enabling multi-sensory channels of communication to be used, including verbal, non-verbal, spoken and heard. Bell and Waters (2014) note that a particular advantage of the interview is its flexibility and adaptability. A skilful interviewer can probe responses, investigate motives and feelings and responses can be developed and clarified. There are three main types of interviews that are consistently mentioned by researchers: structured, semi-structured and unstructured (Bell & Waters, 2014; DiCioo-Bloom & Crabtree, 2006; Gill, Stewart, Treasure & Chadwick, 2008; Menter et al., 2011). Although it is noted by researchers that there many other types of interviews (Cohen et al., 2011). Structured interviews require the interviewer to ask the predetermined questions exactly (Menter et al., 2011). There can be no deviation from the structured questions and no scope for follow-up questions to elicit elaboration from participants (Gill et al., 2008; Fontana & Frey, 2000). Structured interviews are often described as 'verbal questionnaires' and are primarily used to collect quantitative data (Gill et al. 2008; Menter et al. 2011). Semi-structured interviews require some form of predetermined, open-ended questions, but allow room to deviate from these main questions to explore responses (DiCicco-Bloom & Crabtree, 2006). Semi-structured interviews are primarily considered to collect qualitative data. Unstructured interviews are often described as ethnographic (in-depth), and are regularly used in conjunction with participant observation (DiCicco-Bloom & Crabtree, 2006; Fontana & Frey, 2000). The questions for the unstructured interview arise from the observations and are used to elicit understandings about the observed behaviour (DiCicco-Bloom & Crabtree, 2006; Fontana & Frey, 2000). Alternatively, when unstructured interviews are not used in conjunction with observations, Gill et al. (2008) explain that they do not reflect any preconceived theories or ideas and require little or no organisation. This section will focus on semi-structured interviews and the advantages they granted to this research.

As stated above, semi-structured interviews were chosen as the best approach to gathering descriptive, insightful data for this research. This method was also chosen due to the small-scale nature of this research, restricting the data gathering to a single method. DiCicco-Bloom and Crabtree (2006) advocate that in qualitative research projects where a single method of data gathering is used, semi-structured interviews are often the sole data gathering source. Semi-structured interviews are primarily a qualitative approach (DiCicco-Bloom & Crabtree, 2006) and fit within the interpretive framework that guided this research. There were many advantages for using semi-structured interviews as the data-gathering method within this study. One advantage was the way the structure allowed the interview to flow as a conversation. There was some structure to the interview and there were predetermined questions, but the nature of this type of interview allowed for deviation from these main questions to pursue an idea or response (Gill et al., 2008; Menter et al., 2011). Menter et al. explain it as “the researcher has a sketch map of the territory to be explored, but the freedom to explore it as he or she will. The map or agenda is shaped by the research objectives but it is open to negotiation with the interviewee” (p. 131). This approach allowed for discussion to understand the principle questions of the study, but also to gain greater insight by delving into or exploring unexpected responses and seeking clarification. The flexibility of this approach allowed for exploration of areas that were important to the participants, but had not been previously considered by the researcher (Gill et al., 2008).

Despite all the advantages of semi-structured interviews there are also issues for consideration. Many researchers comment on the issue of time – to both conduct the interview and to transcribe/analyse the information (Bell & Water, 2014; Cohen et al., 2011; Fontana & Frey, 2000; Menter et al., 2011). There are also issues of trustworthiness and reliability to consider, which stem from the opportunity for subjectivity and bias on the part of the interviewer (Cohen et al., 2007; Menter et al., 2011). Complementing this approach with other research methods is one way of reducing the risk of bias and subjectivity, and therefore, adding creditability to the findings (Menter et al., 2011). Triangulation is the use of multiple approaches of data collection within the same study, thus providing three (or more) points of data that reveal the same findings (Cohen et al., 2007). Triangulation is a powerful way of demonstrating validity, and is often used in qualitative research for this reason (Cohen et al., 2007). This study originally proposed to use triangulation as a way of validating the findings. The initial proposal considered using semi-structured interviews combined with observation of classroom practice and collection of primary documents such as planning resources. These various methods would have been analysed together to give creditability to teachers' comments during the interview and to the interpretation/analysis of the interview, minimizing chances of researcher bias. Unfortunately due to unforeseen circumstances and limitations due to the scope of this study, a single research method was suggested and semi-structured interviews were chosen as the most appropriate single method for data-gathering.

3.4 Research setting

This research took place towards the end of the school year between November and December 2015. Four teachers were interviewed from two different schools. From each school, a beginning teacher and an experienced teacher were sought in an attempt to gauge a wider range of perspectives and knowledge. The researcher, having had no prior interactions with any of the teachers, had no known bias or expectations going into this research. The research consisted of four separate interviews, ranging between 35 – 45 minutes in duration. Each teacher was interviewed individually and the interviews were conducted in locations where the teachers felt comfortable i.e., within their own classrooms, staff room or offices.

3.4.1 The schools

Moana Primary (pseudonym) is a model country school situated in a semi-rural setting in the Waikato area. Being a model country school it maintains a close relationship with a university's education sector, allowing student teachers to train at the school. It is a medium- to large-sized primary school with a decile 10 rating. The decile rating indicates the extent to which students are drawn from low socio-economic communities (MoE, 2015d) and thus is related to government funding. The lower the decile the more funding it receives. Decile 10 is the highest rating available and as such this school receives low state funding. The finding is supplied in most part by parents and the community. The school is well regarded in the community and has a high standing in the education sector.

Aroha Primary (pseudonym) is a small country school in the Waikato area. It has a decile rating of 9. It is situated in a rural area. The school is well known for its contributions to the enviroschools enterprise and the positive impact it has on its community and environment.

3.4.2 The participants

Holly (pseudonym) was a beginning teacher. This interview was conducted as her first year of teaching was concluding. She was currently teaching group of year 3 and 4 students. Holly's background in science consisted of completing a compulsory science paper during her three-year degree.

Joyce (pseudonym) was an experienced teacher with over 30 years of classroom experience, teaching all age groups (year 0-6). Joyce was currently teaching new entrants. However, she had taught year 5/6 in the previous year. Joyce has experienced teaching in eight schools in both New Zealand and England. Joyce's background in science consisted of completing a compulsory science paper as a requirement of her degree.

Natalie (pseudonym) was an experienced teacher with over 23 years of experience teaching ages 0-3. Natalie has been at the same school for over five years. She has a background in early childhood education, which she taught in before completing her degree in education and diploma in primary teaching. Natalie's background in science consisted of completing a compulsory science paper during her diploma. She also chose to study optional biology and chemistry papers during her degree.

Emma (pseudonym) was a beginning teacher with three years of teaching experience. Over those three years she has spent two years with years 5 and 6 and one year with years 2 and 3. 2015 was her first year at the current school. Emma's background in science consisted of completing one compulsory science paper during her degree.

3.4.3 The researcher

The researcher has a degree in primary teaching from the University of Waikato. Through obtaining this degree and during the initial stages of a master's degree, the researcher was introduced to the idea of scientific literacy and NoS. Until this time the researcher considered science a painful, highly demanding subject to learn and detested the thought of having to one day teach it. Her own experience of learning science through her schooling contributed to her distaste for the subject. However, during her degree and subsequent post-graduate studies she experienced science education as it should be taught for the first time. During her post-graduate studies in particular, she began to develop an understanding and appreciation for NoS and scientific literacy. It was during this time that she began to wonder if other educators knew the purpose of science education and the 'new' approaches available for teaching science. This discovery of what science education could be, coupled with her curiosity about what other educators thought about science education, started the initial ground work for this study.

The researcher has experience with planning and teaching science, which helped her relate to the participants, understand specific educational terminology and understand the value of the time used to participate in the interview.

3.5 Data analysis – Thematic analysis

There is no one right way to analyse qualitative data and Cohen et al. (2011) explain the analysis method should once again adhere to the issue of 'fitness for purpose'. They also explain that qualitative data relies on interpretation for analysis, and note that there are frequently multiple interpretations to be made. Due to Cohen et al's assertions that analysis methods must be chosen for fitness for purpose and that analysis relies on interpretations, thematic analysis has been chosen as the method. Thematic analysis relies on interpretation of codes that are presented in the data (Braun & Clarke, 2006; Mutch, 2005).

This approach to data analysis is helpful for interpretive research, as thematic analysis is not used to simply support a theory but rather the theory emerges with the identified theme/patterns. Thematic analysis is the systematic approach of analysing qualitative data to uncover similarities or consistencies, which are given codes. These codes either remain separate, or similar codes are grouped together to create a theme. The discovered themes create the discussion in the research (Braun, Clarke & Terry, 2014). Thematic analysis has two main approaches. Inductive analysis is used to code the surface data, which creates the themes. Theoretical analysis goes beyond the surface content to speculate and interpret theory and underlying reasons and assumptions as to why or how the themes are present (Braun & Clarke, 2006).

Through a process of getting to know the data both semantically and analytically, I used thematic analysis to code themes that were linked directly to the collected data. Once these codes were evident, I was then able to provide discussion as to how and why these themes were present and to interpret underlying contributing factors to these themes through theoretical analysis. Through the use of thematic analysis I was able to identify similarities between teachers' perspectives and beliefs about science education and speculate on possible underlying causes for these similarities.

3.6 Ethical considerations

Ethical considerations are a key aspect of educational research. Every researcher has a responsibility to their participants to ensure they are treated with respect and that their involvement with the research will not negatively impact the participants' lives (Bell & Waters, 2014) – the notion of no harm to participants. All researchers must take cognisance of the ethical codes governing their practice, regardless of whether they are an undergraduate or a professional researcher (Cohen et al., 2011). In this research the governing code of ethics is that of the Ethics Review Committee for the University of Waikato. However, Cohen et al. (2007) also advocate that researchers are governed by their own personal ethics. Being governed by personal ethics ensured that not only were the procedural ethics followed during this research but also ethics in practice were acknowledged and acted upon. Guillemin and Gillam (2004) identify procedural ethics as seeking all relevant permissions and considering all ethical concerns as identified by your governing ethics committee. Ethics in practice refers to acknowledging and reacting to ethical issues that occur during research, or in the field.

The key aspects of ethical concern addressed in this research included informed consent, the participants' right to privacy and confidentiality, protection from harm and the participants' right to withdraw from the project. These concerns are explained and discussion is provided to show how they were addressed in this research project. The discussion primarily relates to procedural ethics, however, ethics in practice was observed in acknowledging the ethical concerns and were reacted to appropriately when they arose.

3.6.1 Informed consent

A central component to ethical principles is the requirement for researchers to obtain informed consent from all participants before conducting any research (Bell & Waters, 2014; Cohen et al., 2011; Menter et al., 2011; University of Waikato, 2015).

Informed consent is given when the participant is aware of what is required of them and has consented to be a part of the research. This process will usually require a consent form written in easily understandable language, setting out the purpose of study, the nature of data gathering and the involvement of the participant (Menter et al., 2011).

Informed consent for this research was sought from both the principals and the participants. The principals were initially approached to request permission for research to be conducted in the school and permission for their staff to be involved. A consent and information letter outlined the purpose and nature of the study (appendix 6). Upon receiving informed consent from the principal, information letters and consent forms were given to the participants (appendix 7). These consent forms were signed once they were satisfied they understood the requirements of the study.

3.6.2 Participants right to privacy and confidentiality

A second important ethical principle is the participants' right to privacy and confidentiality. Participants need to be sure that any personal information they supply for the purpose of the research is not publicly shared (Cohen et al., 2011). However, educational research is conducted with the understanding that the findings will be shared (Cohen et al., 2007). This requirement necessitates taking care when writing the report. It is critical to ensure that information or names that make it obvious who the participants are not included, while still living up to your obligation to share the generated knowledge. One way to ensure confidentiality is the use of pseudonyms for both people and schools. There is also a need to make sure that any information provided to the researcher is kept safe within a locked cabinet or within a password protected computer where people cannot 'stumble' across it (University of Waikato, 2015).

In this research all names have been replaced by pseudonyms to ensure the participants' right to privacy. All information that was generated by this research will be kept for five years in a locked cabinet and in a password protected computer as stipulated by the University of Waikato's regulations (2015).

3.6.3 Protection from potential harm

Another key aspect of ethical consideration in educational research is that all participants be protected from any potential harm that may arise from their participation. According to the Ethical Conduct in Human Research and Related Activities Regulations (University of Waikato, 2015) harm includes stress, emotional distress, embarrassment, pain, fatigue and exploitation. It is the responsibility of the researcher to be aware of this potential for harm and to take steps to reduce the risk as much as possible. Cases where participants are recorded, such as with this research, can cause some participants to become stressed or emotionally distressed by what they perceive to be misleading or harmful documentation (Ryan, 2011). One way to minimize this potential for harm is to be open and honest with the participants and to share the information gathered with them (Cohen et al., 2006). This protocol was followed during this research by way of a transcript of the recorded conversation being sent to the participants for them to examine. Participants were given the opportunity to dispute the transcript if they wanted to.

3.6.4 Participants' right to withdraw from project

The Ethical Conduct in Human Research and Related Activities Regulations (University of Waikato, 2015) state that participants have the right to withdraw from the research project up until the analysis has commenced on their data. This means that until the data has been accepted and analysed, the participants have the right to recall any data or information gathered throughout the study. Ethically a researcher must make this known to the participants. In this research, the right to withdraw was expressly stated on the consent form signed by the participant. It was also discussed before the interview was conducted to ensure the participant comprehended until what stage they had the right to withdraw.

3.7 Chapter summary

The interpretive paradigm was the framework underpinning this research project. Through the interpretive paradigm guidelines, this research was concerned with qualitative data, gathered by means of semi-structure interviews. These interviews allowed for insightful conversations that elicited participants' perspectives and beliefs on science education and their own teaching practice. Thematic analysis was the analysis approach considered most useful for this type of research and was used to code the findings into four themes. There was discussion of the ways to reduce possible bias and to increase validity and reliability.

Ethical concerns pertinent to this research were considered and discussed in this chapter. The ethical considerations helped ensure that the research was conducted in a way that was enjoyable and relaxing for both the researcher and the participants.

The next chapter presents the findings and the analysis of the research. The findings are stated and then coded into themes using thematic analysis. These themes will be discussed in the following chapter.

Chapter 4
Research findings and analysis

4.1 Introduction

Chapter 2 discussed literature concerning the development of science education internationally before focusing on the New Zealand science curriculum and policy for teaching and learning. It examined the ideals and intentions of the current 2007 NZC science learning area. The review identified that science education has a low status in many primary schools and attributed this to the recent emphasis placed on literacy and numeracy. It appears, though, that little research has been conducted on teachers' perspectives on science education, in particular, whether teachers place any importance on the teaching and learning of NoS. This thesis helps to address this gap in the literature by investigating teachers' perspectives on the purpose of science education and the importance of NoS.

This chapter presents the findings from interviews with four teachers from two different schools, Aroha Primary (pseudonym) and Moana Primary (pseudonym). A beginning teacher and an experienced teacher were interviewed from each school. The interviews were semi-structured and had two sections: a practice section on what happens in the classroom, which included discussion about who decides the in-school science curriculum, planning materials used and pedagogy; and a personal perspectives section, in which teachers discussed their opinions and views on the purpose of science education, NoS and scientific literacy and the usefulness and comprehensiveness of the NZC science layout. An analysis of the findings is then presented. The analysis is based on coded themes derived from teachers' responses to the interview questions. The themes reflect similarities in beliefs, opinions and perspectives, as well as practical teaching approaches and planning. There were no significant differences noted in the responses.

4. 2 The interview

The interview consisted of 10 main questions. Question 4.2.2.1, found below, was designed to gain insight into the teachers' backgrounds in teaching and science training. Questions 4.2.2.2 – 4.2.2.4 make up the practice section of the interview, while questions 4.2.3.1 – 4.2.3.6 explore the personal perspectives of the participants. Some of the questions had sub-questions to cater for the natural flow of the interview if the need for more questions became apparent from responses. Section 4.2 of the chapter presents the findings from the main questions with reference to relevant sub-questions. As stated above, the interview was separated into two sections: practical and personal perspectives. The practice findings are presented first followed by the personal perspectives.

4.2.1 Classroom practice questions and findings

The purpose of asking the classroom practice questions was to find out how much control teachers perceived they had over the science area of the curriculum, that is, whether there was formal structure in science planning and teaching, either school- or syndicate-wide, or whether the teachers felt responsible for the planning themselves. These questions sought to investigate the types of pedagogical approaches currently being used to teach science. The questions also aimed to find out how often teachers taught science and whether it was a set subject or integrated into 'themes' or 'topics'. The findings for each question are now presented.

4.2.1.1 How long have you been teaching and was science training an aspect of your teaching degree?

Two of the four teachers were beginning teachers: a first year, Holly, and a third year, Emma. Two were long-service teachers: Natalie had 23 years teaching experience and Joyce had 30 years experience. Holly and Natalie teach at Moana Primary and Emma and Joyce teach at Aroha Primary. The schools are described in Chapter 3.4.1.

All teachers reported that science was a compulsory element in their degrees/diplomas, and consisted of a six-week paper in the first year of their teacher training. One teacher, Natalie, also took biology and chemistry as optional papers during her degree in education, but none of the others took optional science papers during their training. In her interview Natalie explains that her degree was slightly different from the current degree in primary teaching offered at Waikato University. (Note the interviewer's questions/and/or comments are in bold)

> ***During your degree was science part of the initial teacher training?***
> *Yes it was, the curriculum science. Because I did a diploma, there was the curriculum science but in my degree I did some science as well.*
> ***So in your diploma was it compulsory to do science?***

Yes, all curriculum areas were.

So with your degree it was also compulsory?

No, it was a choice. So I chose to do biology and a bit of chemistry. But I took biology further on.

What was your degree in?

In Education. When I was at teachers college, our diploma and our degree went side by side and we did the whole thing over 4 years.

Oh okay. So your diploma was in teaching and your degree in education?

Yes. (Natalie)

None of the teachers had any additional training in science and none of them have had any post-training professional development in teaching science.

4.2.1.2 Who decides what topics (context), concepts and skills will be taught and when?

The findings from this question indicated that the schools' processes for implementing science programmes and ensuring they are being taught were very different. Differences were also revealed in teachers' perceptions of who plans and decides the content. While teachers were in agreement with some aspects of who decides contexts, concepts and skills, they appeared to differ slightly on other aspects, even though they were from the same school. Teachers from both schools agreed that management was responsible for dictating the science programmes and their implementation, but differed in their perception of who decided on the content and planning. How these schools teach science is explained in two different ways – strands and topics. Holly and Natalie from Moana Primary said they are given a strand (which is one of the five strands set out in the science learning area of the NZC) to teach each term. At the time of the interview, the strand being taught was the Living World. This choice was made by management and was school-wide. The teachers were then grouped according to syndicates.

At this point, these two teachers differed in their explanation on who decided content. Natalie explained that as a syndicate they decide on an achievement objective (AO) and desired skills and strategies.

> *Although we have a strand of science that we cover each term, the teachers can choose what topic or unit you are going to do within the strand. So as a syndicate, because we do our inquiry planning together, we decide as a syndicate what we are going to do.*
> ***So say the strand is Living World, as a syndicate you would choose….***
> *It's more the objective that we choose together and then we try and get a unit that's going to fit with that objective. So even though we might be doing Living World there will be one certain AO that we need to cover. So as a team we decide how we are going to cover that AO. So because we know what we've done in the past we can think of a different, more exciting way to do it this time.*
> ***So you choose the AO and then what context?***
> *Yes, and the skills and strategies that we want as well*. (Natalie)

Holly, from the same school, advised that her syndicate leader wrote the unit plan, providing the concepts and skills. It was then up to the individual teacher to decide on how they wanted to deliver the concepts and skills within their classroom.

> *At the moment we are actually doing a science focus this term. It was decided school-wide to do it. And actually I think all of the syndicates are doing Living World. So that was pre-decided. It was decided by management basically. We don't really have a choice.*
> ***So what gets taught, it's not really up to you as a teacher?***
> *I can only speak for my own syndicate, but we would do an overall unit plan together and our syndicate leader has a big influence on that. She actually writes up the unit. So she might changes things. And then from*

there we can teach it however we want to kind of meet those criteria we've come up with.

You're given the concepts skills and topics to be taught, but you decide how you are going to do that?

Yeah

And do you like that approach?

I do, as a beginning teacher. I think it's much more structured and it's easier for us to handle it as beginning teachers who don't have that experience yet. Especially with having so little PD in it, how are you supposed to? (Holly)

The other two teachers, Joyce and Emma from Aroha Primary, explained that they are given an overarching topic each term across all curriculum areas and science is taught within that topic. Water was the topic for the school at the time of the interview. They differed in perception as to who decided upon the topic, but the topic-based curriculum structure was instigated by management. Emma indicated that the topic was a decision made by all the staff:

So who decides what topics, concepts, skills will be taught and when?

Um the whole staff, and that's usually at the beginning of the term. We have like a planning day where we sit down and discuss what our topic is going to be for the term and what strands we can fit in and how we are going to teach them and just throwing ideas around on the table really.

So who decided to do water?

The whole staff. All of us did. (Emma)

Joyce was unsure who made the decision but guessed it might be management.

Well I think in this school, because we are an enviroschool that underpins everything that we do. I don't know who made the decision that water was the question that we would be looking at, but, umm I guess *management decided on that. From that we went to groups to plan together.* (Joyce)

Emma felt very involved with the planning and organising of the topic but Joyce felt the decisions were made for her. Both teachers reported that once the topic had been given/decided, they met in syndicate groups to plan the details for all curriculum areas that would be included within the topic. Science was considered a focus within the topic and strands from the science curriculum were expected to be covered within the duration of the topic. Syndicates decided on what science strands would be included. However, the interview found that neither of the teachers were sure which scientific concepts or strands were included within their current topic. Emma spoke about "fitting in" as many science strands as they could, but was unable to name one.

> ***So what kind of science strands are coming in under the water [topic]?***
> *Oh gosh, there's no curriculum [to look at]. Umm I don't know*
> ***Okay, well do you focus on a specific strand or are there a few?***
> *Try fit in a few, yeah, if we can. For us water [has been] over two terms so as much as we can fit in the better and that's only because our massive enviroschool presentation that is on Thursday, is on water. So that's why it's had to run for so long.* (Emma)

Emma also reported that the school's principal was involved in the topic planning day, indicating awareness of how and what teachers are planning for science.

> ***Does the principal have much say in what's going on?***
> *Umm she is definitely there and involved in our planning and she often questions us, like have you thought about doing this, or what about doing this or why are you doing it that way? So yeah she definitely knows what's involved but when it comes to actual physical planning, no she's not there.* (Emma)

Joyce admitted that she personally did not plan for science the same as other teachers in the school. She indicated that her syndicate meets to decide on science strands, but she does not always follow this plan.

> *As a new entrant [teacher] I find you can't do that. I see my job as teaching them literacy and maths so how to read and write and then the topic … you know you can't get enough stories around water. If there was, you'd use them. But no, it [science] was purely a topic-based thing that I did in the afternoons. Although in saying that you could incorporate it into your writing.*
> ***Okay so syndicates plan units, however you adapt your planning to suit your kids?***
> *Yeah.* (Joyce)

The findings from this question showed that teachers perceived the planning process differently, even when they were from the same school. Science was taught as a topic or strand, either completely integrated or stand alone in the two schools. Management appeared to make the major decisions around implementation of the science curriculum and was involved to some extent with the planning for science. All teachers talked about working within a syndicate for planning. However, the interviews indicate different perceptions of roles and functionality of syndicates even within the same school.

4.2.1.3 Are there any particular pedagogical approaches you use when teaching science?

Interestingly, both beginning teachers were unsure what was meant by 'pedagogical approaches'. Emma stared before laughing and exclaiming,

> *Don't laugh at me.* (Emma)

Holly requested more clarification, and continued to remain unsure throughout the question.

> *You'll have to be more specific, sorry.* (Holly)

With a little probing, and clarification of the question, the interviews showed that there were a variety of ways teachers approached teaching science. Two teachers disclosed having a 'hook' or source of engagement for the students at the beginning to generate interest in the topic.

> *We always start with a hook to engage the students. Is that what you mean?*
> ***Yeah, go on***
> *That's usually syndicate wide, we use a hook to engage for the whole unit and then for each lesson from there we do the usual thing of sharing our learning intentions, having an individual hook in the classrooms. And then posing what they know about the lesson and then giving them a chance to explore it themselves first before I tell them a whole lot of stuff or we do activities. Is this what you are looking for? I'm not sure.* (Holly)

> *Well its inquiry based. So starting with what the children already know and getting them sort of bombarded with lots of things that are going to motivate them and intrigue them in the beginning.* (Natalie)

Emma and Joyce spoke of using hands-on activities to both engage students and to develop their understanding of what was being taught.

> *Umm visuals. Most of my kids are visual learners. So I try make sure they have those hands-on experiences. Umm for them to actually learn and understand. And not just once, but more than just seeing something*

happen once. They need to really grasp it and the more they see it, the more they understand. (Emma)

Joyce's approach involved developing understanding through scientific investigation. Explaining her approach in the context of the school science fair, she described how students experienced hands-on investigation skills.

A few years ago I did wind power toys and we went over to the wind farm at Raglan and from there they learnt the concept of the wind causing the arms to go around into cogs and from there, one of my achievement objectives were "investigate examples of simple technology devices and link these with some scientific ideas". So we did that in about 8 weeks. And it was a science fair thing, so they had to define the problem, gather the information, analysis it. They kept a logbook, had a design and plan, evaluate. (Joyce)

At this point, teachers began to give examples of resources used rather than approaches to teaching. For example, Emma and Natalie included using digital technologies in their science teaching. Natalie commented:

And I think probably too with what's available now, compared to years ago when I'd teach science, in regards to digital technology, that's driving us in different directions as well. Because the knowledge is there at the finger tips so it's not so much about the knowledge at the end, but how we get there. (Natalie)

Natalie's response indicated she used digital technology to enhance learning and broaden the scope of what could be explored, and how. Emma, however, explained her use of digital technology as a replacement for pen and paper, but still focused on reading and writing.

I use a lot of YouTube and a lot of online bus tools. Like for example with water we have done a lot. I've done a lot of research behind – like the

> *water websites we've put in our blogs so they can go home and look through and we've explored it in class, but part of their homework is to spend half hour on the blog, and look over what we've learnt as a revise and refresh thing. Umm otherwise that's probably about it.* (Emma)

The findings show that only one teacher, Natalie, talked specifically about using student inquiry as an approach to teaching science. She used the above-mentioned resources within the inquiry, but inquiry guided her teaching. In her class students asked questions and shared in finding the answers. She was there as a guide to ensure students' questions and learning were consistent with the topic:

> *We have an overall, overarching big idea that we need to get to. But we allow the kids to direct how we get there. So even though we do a syndicate plan[ned] unit together, each classroom might have a little bit of a spin on it because it will depend on the children's interest and what they bring up in their discussions…. It's the inquiring mind and working with, 'Here's a challenge. How can we solve it?' So giving them the skills to be independent life-long learners.* (Natalie)

Other than Natalie, who used an inquiry-based approach, Emma was the only teacher who indicated any awareness of any developed or established approaches to teaching science. She had heard about the 5 Es (Primary Connections, 2016) approach to teaching science units at university but had never used it (or any other). All teachers described using materials or resources they had, or could find online. However, Moana Primary used Ministry of Education developed resources (Building Science Concepts (MoE, 2016)) to support science teaching and learning. Natalie showed how the books provided the context, concepts and AOs for the learning. However, an examination of these publications showed they did not contain any established pedagogical approaches for teaching the content.

These findings demonstrated that while these teachers used many different resources to teach science, they were limited in describing pedagogical approaches. Only one teacher expressed using a student inquiry approach to science teaching and learning. One other teacher had heard of an established approach to teaching science (5Es approach), but did not use it.

4.2.1.4 Are there any particular planners or planning approaches that you use?

The interview findings reflected a mixed approach to planning among these teachers. Emma and Joyce mentioned that they used a topic planner, and that within this planner was a section for the inclusion of science. They did not use a specific science unit plan. Joyce explained the topic planner as

> *At this school we try something new, called iUgo. It made sure we encompassed all levels of learning.* (Joyce)

Emma also commented that they used online resources with pre-made lesson plans to assist in planning for lessons.

> *We use… Environment Waikato, for example, has a lot of planning stuff for the likes of water, so we've used that as much as we can.*
> ***Do you find that their planning relates to the curriculum?***
> *Yes, yes, they have designed it around the curriculum* (Emma)

Holly noted that Moana Primary had a generic unit planner that all syndicates used to plan topics, but she created her own lesson plans.

> *Well, we have a generic unit planner, and that's syndicate wide, obviously. And then from there we may create our own lesson plans … if you want to call it that. Kind of outlining each lesson.*
> *So for example, we are doing Living World at the moment and we have our overall unit plan. But I've broken it down into lesson one, is [its] finding out what's living and non-living. Lesson 2 is finding out the role of bees. Lesson 3, pollination. And I do it like that.*
> ***You make those lesson plans yourself?***

Yeah, yeah. (Holly)

Natalie reported that the school changes the planners used intermittently.

> *We use the source model at the moment. But we have trialed a few different models over the years.* (Natalie)

The findings show that there is no consistency with planning for science even within the same school. Science planning had no clear format, and teachers did not use specific science unit/lesson planners. There seemed to be 'generic' planning templates that are used, but the interviews did not reveal where these templates came from. The study found that none of the teachers used specifically designed science planning templates themselves.

4.2.2 Personal perspective questions and findings

The personal perspective questions were an integral part of this research. They were designed to elicit responses that were personal to the teachers. This part of the interview aimed to find out how teachers felt about science education, what they believed to be important and how much they valued science as a curriculum area. They were also developed to investigate the importance teachers placed on NoS and scientific skills in their teaching of science.

4.2.2.1 What is your understanding of the purpose of science education? Why do you teach it?

The study found that this question generated two main responses, in which the teachers outlined the major purposes of science education. Every teacher said they believed the predominant purpose of science education was to teach students how the world works and to develop an understanding about the world. According to these teachers the purpose of science education is:

> *Building their knowledge of the world around them.* (Joyce)

> *Understanding the world and how the world works … it also answers a lot of 'I wonder's … That wanting to know the answer to things.* (Natalie)

> *To teach students about the world, how everything works … really understanding about where they come from, their environment.* (Emma)

> *It's important for them to understand how things around them work, grow. Just how nature works … it also opens them up to ask their own questions about things. It gives them an inquisitive mind.* (Holly)

Three teachers, Holly, Natalie and Joyce, stated that science was also taught for the purpose of developing inquiry and questioning skills in the students. Interestingly, these teachers included inquiry as an important element of science education, however, only Natalie spoke of using inquiry as an approach to teaching science. Natalie explained that developing inquiry encouraged students to want to find answers to things, and work through challenges which developed independent learning.

> *Children are naturally inquisitive, and to use that inquisitive nature is actually going to bring them a step further in their lives. Like when it comes to vocab enrichment and just understanding the why of things. And also it gives you the opportunity to encourage independent learning. That wanting to find the answer to things and wanting to set up challenges and work through things and not always accepting other people's answers, but gives them a chance to think about things.*
>
> (Natalie)

Joyce linked students inquiring about new things to building their knowledge.

> *So you are building their knowledge of things that happen in the world and what we've learnt and what we can learn. Hmm. So you are providing opportunities for them to inquire in different ways and then building their knowledge.* (Joyce)

Lastly, Holly explained inquiry in science as encouraging students to think about their own interests and giving them the opportunity to pursue these interests, building their excitement for science.

> *Opens them up to ask their own questions about things. It gives them an inquisitive mind if you give them the option of looking into things that excite them.*
>
> ***So gets them to think about what they are interested in?***
>
> *Yes and like inquiry. Use it a lot in getting them to come up with things. Like what do they know about something, what are they going to know?*
>
> (Holly)

Teachers also commented on other aspects of the purpose of teaching science, which were varied. Holly mentioned students' potential careers and professions as a purpose of teaching science. Natalie and Joyce explained their reasons why they taught science rather than giving an overall purpose of teaching science. Joyce gave the rationale that children have different gifts or strengths and it was the responsibility of the teacher to ensure exposure to students of all learning areas. Natalie explained that she taught science because it was in the curriculum and, therefore, mandatory.

In summary, the findings showed there are two main purposes of teaching science for these teachers. One was to give students an understanding of the world, and the other was to develop inquiry and questioning skills. These teachers commented on other aspects of the purpose of science education, but they were not given as main purposes. These other aspects referred to the teacher's responsibility to ensure exposure to all learning areas and science education being mandated through the curriculum, rather than its purpose.

4.2.2.2 What do you want your students to get out of your science lessons?

The responses for this section were more widely spread than in other areas of the interview. While some teachers' perspectives aligned in some aspects, there were also a variety of responses. Emma and Holly both talked about content being a key aspect of their science lessons. They expressed how they wanted their students to develop an understanding of scientific concepts being taught and to learn new things. For Emma, fun and enjoyment was central to her lessons, followed by a specific content focus.

> *Fun and enjoyment, umm, being able to understand content knowledge as well as, umm, I guess just being able to explore and experiment, kind of develop a new understanding in a way that they can understand so that things makes sense to them. If that makes sense?* (Emma)

Holly was also focused on content, but indicated that engagement with the topic was also important.

> *Learn something new. Cement what they already know. And feel confident to share what we've learnt. And also to get them to question more than what I've already taught them. Like, get them to go away on their own and sort of come up with more things they want to do, not just what I give them.*
> ***So kind of get them engaged and excited about the topic so that they themselves investigate it?***
> *Yeah.* (Holly)

Joyce wanted her students to get 'understanding' from her lessons. However, she did not specify developing scientific concept knowledge as an outcome, and was unsure if her science lessons involved scientific concepts. She gave a specific example of what she was currently teaching, and what she wanted the students to get out of that lesson.

> *Umm, the understanding. Our question was "what is healthy water?" So we began with cut out pictures of very dirty water and clean water and*

in-between and I had 3 hoops and we had to categorise them. So that was the beginning of being able to observe. To make observations.

So when you say 'understanding', what was it that you were trying to get them to understand with that illustration?

What healthy water is, looks like.

So would you say concepts? Scientific concepts?

Umm I suppose… is healthy water a concept? Well, we needed to know what healthy water looked like before we could go to the next stage of knowing where to get it or how to change dirty water into clean water. So you had to build a basis of understanding first. Like filtering the dirty water through newspaper, was like the next step.

Okay, the understanding being the building of knowledge?

I don't know if it was a concept … (Joyce)

These statements by Joyce indicate she was not sure the 'understanding' was about scientific concepts. She taught a topic, in which science was incorporated (during the planning stage) but was unsure of when the 'science' was specifically taught, but that it was covered generally in the topic.

Conversely, Natalie's response showed that acquiring new knowledge was not the main point of her lessons but rather developing the skills and strategies for discovering new things was more important.

I think the biggest thing is, not necessarily the knowledge, but the skills and the strategies of discovering new things. So I'd like them to think 'if this is the case for this, I wonder why it works with this'. So encourages them to be a bit more self-directed in their learning. I think all the way through, science is not just 'in the science time', like 'now we are going to do science' - in the junior school I'm thinking. Because it's a daily, all the time type of subject. Because it's what's around us and it's how we, how our world works. So there are opportunities right throughout the day to be talking about things that are science. So that may be why children *don't always know that they're learning science because it's integrated throughout the day.* (Natalie)

Natalie was the only teacher to mention teaching skills for learning.

From this section we can see that all teachers had different expectations of what students would learn or get out of their science lessons. Some agreed on some aspects, such as the importance of content and learning, and engagement and interest in science as an important component of their classroom practice. One had a very different purpose for teaching science in their classroom. This purpose related more to developing skills in learning and an appreciation that science is all around us, happening all the time, rather than acquiring specific content knowledge.

4.2.2.3 What does the nature of science mean to you? How do you include NoS within your planning?

The initial findings showed that none of the teachers knew what NoS referred to in the NZC or had any particular understandings or beliefs about NoS themselves. The findings showed a consistent lack of understanding of NoS regardless of how long teachers had been in-service or when they received their initial teacher training. For example, Natalie and Emma displayed uncertainty when asked about NOS, especially regarding planning.

What does the nature of science mean to you?

How do you mean?...

I'm not 100 percent sure to tell the honest truth. No. I mean, I'd say that it comes under what we do on a daily basis, but I actually must admit I don't look into to make sure that we're doing that part of the curriculum document as such.

So it's not explicitly taught or planned for?

No. It's probably in our science units, if I had a look I'm sure it'd be mentioned but it's not something I refer to all the time.

… It's not specially planned for?

To tell the truth I'd have to have a look at my planning assessment book that's in my classroom. Because I'm sure that … because we have taken it all from the different things that are in the curriculum, but I can't remember …. Quite often, it's just put there on paper. We know we have our big idea that we are going towards, and then we just tick the boxes for the other things in the planning. (Natalie)

I don't even know. Oh god, that's such a tough question.

Take your time to think, that's fine.

What does the nature of science mean to me? Umm it's like your real understanding and your grasp of science concepts and, I guess, for us in our planning, it's just like a tick box. You know, this is what we're going to do, this is why we're going to do it and this is what we are going to focus on. I've never really stopped and thought about its importance. You know when you're doing your planning things are really general because you've got so much to do … I've never really stopped to think about it. You just take things for granted [that it's in there].

At university during your degree, did you go over NoS – what it is and why it's in there?

Nope. Well, we probably did, but I don't remember. I don't feel like we did ... But a lot of the curriculum isn't explained to you at uni[versity]. You know, it's just something that's taken for granted. This is what's written here, now understand it. And that's it.

So when you are doing your planning you don't particularly give thought to what areas of NoS you'll be covering?

No not really. God, you're making me think! Far out. (Emma)

Natalie's response is similar to Emma's, even though they are from different schools with more than 20 years difference in experience and completion of degrees. The findings indicate that both Natalie and Emma lacked knowledge of NoS and how it is intended to be included in their planning. While neither had considered this element of the curriculum or thought to check that it was included in the planning, they were sure that if it was in the curriculum their plans would reference it somewhere. Both referred to planning in science as a “tick box” process, rather than something they “stop and think about”. Neither had included NoS in their own lesson plans and neither had specifically taught NoS.

Joyce did refer to aspects of NoS in her response, although her explanation was not detailed. She indicated that having NoS incorporated in planning “would be good” but it was not a priority.

> *I think the word investigation comes to mind ..., I think investigation, questioning.*
> ***Okay, so that is your understanding of NoS? The investigation and the questioning?***
> *Mmm yes.*
> ***So how do you include that in your planning?***
> *Well when you plan, you know what you want to end up with, so you have to go backwards in a way and think how am I going to get to that end?*
> ***Okay, so if you look at NoS it's got 4 different strands with achievement objectives for each underneath. Do you specifically include those AOs into your planning? Or the strand headings?***
> *I think you have your main concept that you want to zero in on, and you have to do that.*
> ***You mean a scientific concept?***
> *Yes, the point of teaching that lesson*
> ***So would you incorporate NoS into that concept learning?***
> *Umm yeah you'd incorporate it.*
> ***In your planning, you have your learning intentions, etc., do you have NoS learning intentions that you include in there as well?***

Umm probably. That would be good. Whether you reach them or not, you know. But if you haven't made yourself aware of them I think you lose it. You've got to be on track. (Joyce*)*

Joyce makes the case in this section that teachers should be aware of NoS, and it would be good to include NoS in the planning to "stay on track". However, she provides no detail about how she includes NoS. When talking about NoS she refers to aspects of investigation.

Holly is unaware of the meaning of NoS and cannot explain how it was included in her planning and teaching.

What does the nature of science mean to you?

Oh my word. What does that mean?

So, the nature of science in the curriculum, the overarching strand. What does that mean to you? Why is it in there?

I guess it kind of links to one of the questions we had before. It's around the children and they need to understand the world that we live in and how things work … I have no idea.

So do you plan for teaching the nature of science at all in either the lesson plans or unit plans?

I don't know if it's included in the unit plan. I actually don't know. I couldn't tell you.

So when you do your lesson planning do you look at the nature of science strand?

It's more that I look at the strand [that's being taught]. It's very specific.

So you wouldn't say that you specifically teach NoS?

No. We have a theme that we teach. Like electricity.

But within that theme, do you teach or allow for exploration of NoS?

I don't actually understand what you are asking to tell you the truth. So obviously not, because if I don't know what you are talking about then I obviously don't do it. (Holly)

The other teachers did allude to an awareness that there was an element of NoS in the NZC, but reported that they just do not consider it in their teaching, or know much about it. Holly's response shows that she has never heard of NoS before.

The findings from this question revealed none of the teachers could explain what NoS was, what it meant to them, or the role it played in science education. Joyce touched briefly on investigation and questioning but was unable to explain it further. Although none of the teachers was confident in their knowledge of NoS, three of them were able to give some explanation as to how planning in science included NoS. Their responses, although given separately, were remarkably similar. They were all sure elements of NoS would be specifically stated within unit planning somewhere, although none could give the particulars of how NoS was included within their own or their syndicates' planning. Emma and Natalie admitted that unit planning within syndicates was more concerned with 'ticking the boxes', but were sure that if it was in the curriculum their plans would reference it somewhere. However, neither of them considered this element of the curriculum or thought to check that it was included in the planning. Neither had included NoS in their own lesson plans and neither had specifically taught NoS. Joyce indicated that, although NoS was probably included in the planning, it was not a major focus in her classroom and she was unconcerned whether students achieved NoS AOs.

This section of the interview found that the teachers gave limited consideration to NoS in their planning and were unable to state with certainty that NoS was a part of their respective syndicates' planning. The findings also show that three of the teachers admitted to never consciously teaching NoS, and one was unconcerned if students did not achieve the AOs of NoS.

4.2.2.4 Have you ever heard of scientific literacy? What does it mean to you?

All four teachers stated that they had never heard of the concept of scientific literacy before. For example, Holly gave the response:

Have you ever heard of scientific literacy?

No.

The next question is what does it mean to you. Do you want to answer it?

Um like researching. Students doing research on science concepts? I'm not sure. Sorry, that's probably not good or helpful. (Holly)

While Emma, Natalie and Joyce were unsure of the term, they guessed that scientific literacy was concerned with terminology and vocabulary – it was the language of science.

Have you ever heard of scientific literacy?

Ah no. not specifically.

If I asked you to explain what scientific literacy was, and what it means to you?

I'm guessing it would be like words associated to science, like terminology and different words that you'd use within science. For example, like words that get thrown around at this age so that they hear them so that when it comes time to when they have to break the terms down and fully understand [them], it's not something that's totally foreign.

(Emma)

Have you ever heard of scientific literacy?

Umm no more than when it comes to math literacy – making sure they have all that vocab in place. (Natalie)

Have you ever heard of scientific literacy?

Umm where?

Well, if I was to say 'scientific literacy, what does it mean to you?' what would you think that would include?

Uh terminology.

Okay, so it would be concerned with scientific terminology?

Yes, building the children's literacy. You know, you want to teach them the correct words and terms. (Joyce)

While unsure of its meaning, the other three teachers felt scientific literacy was an important aspect of science to teach because it is important for the students to understand and use correct terminology and vocabulary. These three said they model and teach specific terminology and vocabulary relevant to the topics or strands they are teaching.

The findings showed that none of the teachers had had any exposure to the term scientific literacy and were unsure of its meaning. It was found that the teachers considered scientific literacy to be related to vocabulary and terminology of science.

4.2.2.5 Do you plan for scientific literacy? How?

The teachers considered scientific literacy to be developing vocabulary and terminology of science and explained that specific key terms or words were considered and written in their lesson plans to teach the students. It is in this way that they plan for scientific literacy.

4.2.2.6 Do you find the NZC layout/design for science helpful and easy to follow? Do you understand what you are required to teach in the science section of the NZC?

All four teachers had a different response to this question. Emma did not find the NZC science section helpful in both terms of content and structure.

No. not at all. It's so crap.

Why, why do you think that?

Because it's like level 1 and 2 are basically the same. So many similarities. It's like they want them to be broken down into more explicit things. You feel like you are teaching the same thing, there is no *difference. And they use words like "will explore". What does 'will explore' mean?*

Do you find it easy to understand what the NZC is requiring of you in your planning/teaching?

No. no, no. There is so much variety, I guess, you want it to be narrowed down a bit. Umm and I guess put into more sections. Does that make sense? I don't know how to explain … because there is so much to cover, science is such a general term that it would be ten times easier if it was more succinct I guess … It's too vague, too open to interpretation. It needs to be specific in what the students will learn. Would be way easier if it just told me what to do. Like with maths, it's all broken down into the different areas and its way easier to understand. [Science] needs a little more structure. (Emma)

Natalie confessed that she was unfamiliar with the science section of the NZC so was unable to say whether it was helpful. She advised that she does not use the NZC to plan, but uses other Ministry of Education produced books which she describes as being a little bit more user-friendly.

I haven't really looked at it in great detail because, with a lot of curriculum documents you end up looking at them in great detail when they end up becoming professional development with the whole school. And so science hasn't come up as a professional development with the school as such. So then it's up to individual teachers to get to know that document really, really well. And so because as a time saver, I know the document's there, but it's got a whole lot of other books that go along with it. We end up going into the books to get the AOs that are there. So you tend to find you end up doing it the easiest and quickest way that you can. And there are a lot of resources that go along with the curriculum document. So really, you find that you aren't really looking at the curriculum – we are directed by what the kids are doing and those other documents which are probably a little bit more user friendly.

> ***So when you say 'more user friendly' are you finding the curriculum not user friendly?***
>
> *Well we use these little books, [Building Science Concepts] that have it all there for you. So a lot of it is done for you pretty much. But they are all developed by the Ministry of Education so they've got to match, you'd think. Since the demand on your time is so huge, you just tend to grab these things because it's all there for you.* (Natalie)

Natalie shows here that her units are written based on these books, which are pre-made units based on a concept. Planning is derived from the content of these books with no reference to the NZC. Even the AOs, which Natalie advises direct the whole unit, are taken from these books rather than the NZC. Natalie assumes the NZC and the Building Science Concepts (BSC) series align because they are both produced by the Ministry of Education. However, by her own admission she is not familiar with the NZC, so she would not know if they align or not. She would also not know whether there were aspects of the NZC missing from her planning and teaching if they are not found within the BSC books.

Holly's response was a mix of the two previous ones. She found the NZC too open to interpretation and does not often use it because she also uses the BSC books in her planning and teaching. She also advised that as she planned within a syndicate with many experienced teachers she felt confident that her planning was in accordance with the NZC.

> *I think it's a little bit too open. We do use, I don't know the names of them, but little green books [Building Science Concepts]. We use those a lot to try and help and bridge the gaps in the curriculum. But as I said I plan in a syndicate so I am with a lot of experienced teaches and so that helps me a lot obviously.* (Holly)

Joyce was the only one to comment that she found the NZC to be helpful and easy to follow. She was very satisfied with the curriculum and felt that she understood its intentions and directions.

> *Yeah I find it helpful. I think it's good.*
> ***You find it easy to follow and understand, and you know what you are required to teach in the science education section?***
> *Yes, I think it's specific.* (Joyce)

These findings found mixed opinions regarding the usefulness and explicitness of the NZC. They show that only one teacher felt confident using the NZC. One teacher was opposed to the NZC and found it completely unhelpful. Two teachers admitted to not using the NZC to assist with planning. One stated that she found the NZC was not user-friendly.

4.3 Analysis and emerging themes

Thematic analysis was the approach chosen to complete the analysis of the data. This is a systematic approach to identifying similarities in the responses and coding them into emerging themes (Braun, Clarke & Terry, 2014). The coding identified four main themes. This analysis section will present the themes identified: limited science training and professional development, low status of science education in primary schools, lack of knowledge about current teaching approaches, and limited understanding of the purpose and importance of science education. These themes and their significance with reference to reviewed literature will be discussed in the following chapter.

4.3.1 Limited science training and professional development

This theme was identified through the teachers' admission that the only training they received in science education was six weeks in the first year of their degrees, with no professional development in this curriculum area during their teaching careers to date.

The following section provides insight into the limited training in science education for these four teachers.

Three of the teachers, Emma, Holly and Joyce, said that their only science education training consisted of one six-week paper that they completed in the first year of their training. Thus overall they had roughly two-and-a-half years without science training or involvement in science while they completed their qualifications. There was a gap of at least three years before they implemented this training in their first year of teaching, assuming they all began teaching at the completion of their degrees and they completed their degrees in the expected three to four years. Natalie was the only teacher to have received additional training in science to support her background knowledge because she took two optional science papers.

None of the teachers disclosed having received any professional development in science education. Natalie stated (section 4.2.2.6) that she had not experienced any professional development throughout her career and she linked this lack of professional development to her lack of knowledge regarding the science curriculum area. Joyce has been teaching for 30 years and also gave no indication that she has ever sought or been provided with professional development in science education. Holly and Emma were just as unfamiliar with the science area of the NZC as the other two teachers, indicated by their comments (sections 4.2.2.3 and 4.2.2.6). Since these two teachers are beginning teachers, their lack of understanding seems to stem from insufficient pre-service training.

This study found that irrespective of when these teachers received their training, they all displayed limited knowledge of science education in general, as evidenced throughout the interviews. This lack of knowledge is analysed in the next section, linking these teachers' limited knowledge of science as a learning area and planning in teaching science to the next theme identified, that of the low status of science education in primary schools.

4.3.2 Low status of science education.

The teachers' responses throughout the interviews support the view that science education has a low status. The term 'status' is used in this research to mean the level of importance assigned. Thus, to say that science education has a low status is to say that science education is regarded as having a low level of importance. Thus status was reflected in the time and detail these teachers gave to planning for and teaching science. This attribution of low status appeared to be passed down from management. Aroha Primary planned science under a 'topic' study, while Moana Primary used resource booklets to assist with their science planning rather than the NZC.

Aroha Primary taught science as part of an over-all term topic, which was 'Water' at the time of this study. They planned for all curriculum areas using this topic. The idea of using a topic to integrate curriculum areas was a management directive and the planning of the topic, including integrated learning areas, was also over-seen by management according to Emma (section 4.2.1.2). The topic planner was called iUgo (a planning and teaching resource system) which allocated sections of the planner to various learning areas. They did not have a separate, science-specific unit plan. Emma also talked about "fitting in science strands" to the topic. This practice indicates that there was no clear focus on science teaching or planning, but rather a "fitting in" of the requirements of the curriculum, which became more evident by Emma's further comment (section 4.2.2.3), where she explained science planning as "just like a tick box".

As Emma indicated, the principal at Aroha Primary was involved with this area of the planning and, therefore, it is assumed that approval had been given to this type of planning. This tacit approval for the approach to planning used by teachers demonstrates a low status placed on science education by both management and the teachers.

Emma was asked about her specific lesson plans, to gauge whether planning was conducted in more detail at an individual level. She admitted using online, pre-made lesson plans such as those from Environment Waikato (4.2.1.4). Emma stated that these lessons were aligned with the NZC, however, she was unable to identify the scientific concepts or the overall strand(s) (from the NZC) that were covered during these lessons.

Joyce, who was also expected to plan according to the topic, gave even less consideration to science concepts in her planning and teaching and admitted that she did not follow her syndicate's planning to teach a topic using a cross-curricular approach. Joyce planned her numeracy and literacy separately and simply taught the topic of water in the afternoons. Joyce explains this way of delivering science (section 4.2.1.2) and specifically states that, for her, science is less important than numeracy and literacy.

The findings showed these teachers were unsure about what scientific concepts or strands they were teaching, without consulting their planning (noted by Emma in section 4.2.1.2, and Joyce in section 4.2.2.2.). The topic of water had been taught for two terms, extending longer than most topics because it was part of an interschool enviroschools presentation. For two terms these teachers had apparently planned for and taught science, yet neither of them were sure which strands from the NZC were used nor which specific concepts students were learning.

Moana Primary use a school-wide generic planner for science in which they plan for and teach one strand per term. As with the other school, Moana Primary's implementation of this structure for teaching the science curriculum was determined and directed by management (see section 4.2.1.2). The choice of strands was also decided by management. At the time of this research the school had a Living World focus. Both Holly and Natalie described different approaches to planning.

Holly's description of her syndicate's planning approach also demonstrates the low status attributed to science education. Instead of having everyone in the syndicate involved in the planning process, collaborating ideas and approaches, one teacher, the syndicate leader, wrote the unit plan. She required the teachers in her syndicate to teach according to this unit plan. Holly (section 4.2.1.2) stated that they "don't really have a choice". However, she also advised that she liked this approach because she was a beginning teacher and felt that she did not have the experience to contribute to the planning. She simply trusted that, because experienced teachers were planning the units, the units would be aligned with the NZC (see section 4.1.3.6). Holly explains that she does not use the NZC to plan because her syndicate leader wrote the plans for her and because they based their units on the BSC books.

Holly demonstrated a lack of understanding of the NZC science area and limited approaches to teaching science throughout the interview. During the planning process, no time was spent ensuring that she understood the concepts or knew what aspects of the curriculum had been included. No time was allocated to ensure understanding of the curriculum area. No time had been spent explaining or demonstrating how to plan effectively for meaningful science education. Holly's trust in the experienced teacher's planning to cover all the requisite elements from the NZC could be misplaced because even experienced teachers do not always comply with the mandated curriculum. Indeed this study has found that, due to the low status attributed to science education, there was an enacted curriculum in the classrooms – these teachers were not teaching according to the mandated curriculum. Planning for teaching science had become a "tick box" approach to appear as though curriculum policies were being followed. Natalie provided details about this enacted curriculum and "tick box" approach, which is discussed below.

Natalie also demonstrated the low status placed on planning for science education through her lack of understanding of the science curriculum learning area and unwillingness to use the NZC in her planning. She said (section 4.2.1.2) that when they plan as a syndicate, they chose a unit that would fit with the school mandated strand, from the BSC resource books and then chose a specific AO from this unit/book. No consideration for or acknowledgement of the NZC was given. Natalie showed that for her, science is not a key aspect of the NZC, or a key consideration in her teaching. This conclusion is drawn from several of her comments.

Firstly, she talked about not knowing the science area of the NZC (section 4.2.2.6). She was waiting for professional development in the area to explain key elements of the curriculum and how they were expected to be taught or included in lessons and planning. In 23 years Natalie has not been concerned with understanding the science curriculum learning area. Natalie trusted that, because the unit books were produced by the Ministry of Education, they were in accordance with the NZC. These books, however, were delivered to all primary schools between 2001 and 2004 (MoE, 2016). This was before the current NZC was published and established. These resource books do not align completely with the NZC as they predate it and were not specifically designed to teach NoS (MoE, 2016). Therefore, since Natalie and her syndicate used these books as pre-made units and did not consult the NZC, it is understandable that they did not know about NoS or plan to teach it. These teachers were using old resources to teach science.

Secondly, in this section Natalie also commented on time constraints being a major reason for using the pre-made units. This comment implies that Natalie prioritised her planning time and planning for science education was given a lower status than other curriculum areas. Consequently she felt she had more important things to do than ensuring she had aligned her planning with the NZC and that all aspects of science education had been considered and planned for. She confirmed her view of a low status for science by further comments such as "Quite often, it's just put there on paper. We know we have our big idea that we are going towards, and then we just tick the boxes for the other things in the planning". Once Natalie had decided on a pre-made unit, planning became more about 'ticking the boxes' to make it appear that the curriculum was being taught. This is evidence of an enacted curriculum taking precedence over the mandated curriculum. Emma admitted to doing this as well, and Joyce and Holly implied it happened with their planning in science.

This is a clear indicator that these teachers considered science less important than other aspects of teaching. Planning for science is done through a process of 'ticking boxes' and science is taught according to an enacted curriculum, not the mandated curriculum. Science has such a low status that these teachers did not feel the need to give real consideration to their planning and teaching in this area; rather the appearance of consideration would do. What is perhaps more worrying is that management were aware of this planning approach and the use of an enacted curriculum and appeared to support it, thereby cultivating the notion of low status of science in their schools and, by extension, in the primary education sector.

The above findings clearly show a low status ascribed to science education in these primary schools. This status appeared to be school-wide, with management seemingly unconcerned with details of planning or how science was taught. This attitude was mirrored by the teachers, demonstrated by their minimal efforts applied to science planning and their failure to plan in accordance with the NZC. Time was also a factor in the teachers' lack of planning in detail for science and for not using the NZC. This implies that the teachers considered they had more important things to do. Ultimately these findings show that both the management and these teachers ascribed a low status to science education.

4.3.3 Lack of knowledge regarding current teaching approaches in science education.

The third theme identified is the teachers' apparent lack of knowledge regarding current approaches to teaching science. This theme was identified due to the teachers' limited understanding of pedagogical approaches to teaching science. What became obvious during the interviews was that these teachers' approaches to teaching science were largely traditional. These traditional approaches were hidden in more current terminology. The teachers considered that they were teaching according to current approaches because they used current tools, such as computers, internet, and 'inquiry' (where inquiry consisted of just asking questions). However, it became apparent that these teachers' attitudes and dispositions towards teaching science were still orientated towards traditional teaching.

Below are examples from each of the teachers showing the traditional approaches used, and how they were integrated with more current terminology.

Emma disclosed (section 4.2.2.2) that scientific content was a major focus in her teaching. Content-led science teaching is a traditional approach (section 2.2.1). She talked about using computers and the internet (section 4.1.2.3) to assist in her teaching of scientific concepts. However, she explained that they were used mostly by way of a blog – students read and wrote their learned knowledge. The recording of knowledge through writing and the approach to reading as learning is traditional. The only thing Emma changed about this traditional approach was the medium in which the students read and wrote. Instead of a book, it was a screen and instead of pen and paper, it was a keyboard. Emma also talked about using hands-on activities as inquiry. However, her description of how she used inquiry indicates she had only a limited understanding of the inquiry approach. Emma did not explain how she focused on scientific concepts in her inquiry approach. Rather her explanation (section 4.2.1.3) gives the impression that through hands-on interaction and experimentation, students would develop understandings about the concepts themselves. Emma did not disclose how she might then elicit understandings or address misconceptions, and there was no mention of discussion. This indicates a limited understanding of current approaches to teaching science. She seems to be trying to include the more current approach of inquiry but without teacher-facilitated learning.

Holly also had a content-led approach to teaching science (section 4.2.2.2). In addition, this appeared to be teacher-led. She spoke about what she taught them or what she gave them or what she told them, indicating that learning came from her and her explanations. The comment made by Holly "Before I tell them a whole lot of stuff" (section 4.2.1.3) demonstrates that she dictated to the students the knowledge she considered they needed to learn. Reiterating explanations is seen as a traditional view of science education and is in opposition to the inquiry approach. However, Holly often used terms such as 'inquiry' and 'exploration' when she described her understanding of science education and her expectations of her teaching. This implies a limited understanding of what these terms actually mean and indicates that she does not use them effectively in her teaching practice. Holly appeared to be teaching science using traditional approaches but including some current views on teaching and learning in science.

Joyce's comments also reflected a traditional teaching approach. She referred to investigation as being the approach she used (sections 4.2.1.3 and 4.2.2.3). Joyce said that she used 'the scientific method of investigation' through the context of a science fair. The idea of a single method of investigation, or that all scientists work and investigate in the same way, is an outdated, traditional concept. This would indicate that Joyce continues to teach science as she was taught, reinforcing the idea of 'a single' scientific method. It also indicates some consideration of NoS (how some scientists work and investigate in science), however, this was portrayed in a traditional approach. These findings show that Joyce has a limited understanding of current approaches to teaching science.

The above examples show how three of the teachers used traditional approaches to the teaching of science. Natalie was the only teacher who did not demonstrate the use of traditional approaches to teaching science. Instead she talked about student inquiry and was able to give examples of how it was used to guide her teaching. She explained that teaching science was less about content and more about equipping students with learning skills so that they might become life-long learners (section 4.2.2.2). Natalie clearly understood some current teaching approaches and had used them in her teaching. However, as noted above, she did not follow the NZC and, therefore, did not plan for or teach NoS. Because of this, Natalie talked about developing generic learning skills, rather than specifically developing scientific reasoning, thinking and learning skills to promote scientific literacy. This indicates that even Natalie, who clearly showed some understanding of current teaching approaches, still lacked knowledge of NoS and how to effectively include NoS within her inquiry approach. The omission of NoS limits the benefit of using the inquiry approach.

This section identifies issues with the approaches these teachers used to teach science. Traditional approaches were still being employed in some classrooms for teaching science. Some of the teachers believed they were teaching science according to current approaches because they used current terminology. But when they described their practice, it was obvious they relied on traditional approaches. Natalie used student inquiry, a current approach, but omitted NoS and, therefore, did not comply with the NZC. Natalie is close to including NoS in her teaching, but she is unaware of what NoS is. With some professional development and support Natalie could well be on her way to teaching NoS for the goal of scientific literacy.

4.3.4 Limited understanding of the purpose of science education: What science is, why science is taught and key components of science education

This theme emerged consistently throughout the interviews. It was evident when the teachers talked about their planning, teaching approaches and even their own ideals and understandings of science education and what they wanted their students to achieve from their science lessons. These teachers did not appear to have a clear understanding as to why they taught science or the purpose of science education, and had no personal philosophy regarding the teaching of science. While there were some glimpses of understanding science education, the teachers were often unable to follow up or explain their answers. This theme has identified areas of concern regarding teachers' understanding of the purpose of science education.

These teachers struggled to explain their understanding of the purpose of science education. In the end, all responses concluded that the main purpose of science education was to teach students about the world and develop inquiry skills. The teachers appeared confident that their statements summarised the main purpose of science education and required no further explanation. This view implies that the teachers are not actually sure what science is, how it works or why it is taught. It seems an unrealistic and incredibly exhausting goal to endeavour to teach students everything about the world in all aspects that science can explain or all questions science can answer.

In an attempt to get the teachers to expand on their answers and to divulge what they considered were the important aspects of teaching and learning science, they were asked “What do you want your students to get out of your science lessons?” The answers given were traditionally orientated as indicated in section 4.3.3. Science lessons for most of these teachers boiled down to an understanding of the concepts and engagement in the lessons. Emma, Holly and Joyce spoke of a content-led focus; their reason for teaching science was to encourage students to develop an understanding of scientific concepts. Emma and Holly also said the lessons should be fun and full of enjoyment to engage the students. The teachers were concerned with students engaging in and enjoying their lessons, rather than engaging with and enjoying science – that is, developing an appreciation of what science is about, what it can show/teach/explain, and how they can use science to investigate areas of interest to them. These are skills intended to be gained through the teaching of NoS. The responses from these teachers showed that all of them had a limited understanding about science, and lacked a personal philosophy as to why they taught science.

Analysis of these findings also revealed the teachers’ limited knowledge about key components of science education, in particular NoS and scientific literacy. Although NoS is the overarching strand within the science curriculum, the findings revealed that none of the teachers really knew what NoS was and none of them considered NoS to be an important aspect of science education.

Holly demonstrated a complete lack of knowledge about NoS, as indicated by her response is section 4.2.2.3. She did not know if NoS was included in unit plans and did not plan for NoS herself, or teach NoS skills or AOs. Both Natalie and Emma admitted to not considering NoS in their planning or teaching, although they were both confident that if it was in the curriculum, it would be in their planning. Both expressed planning in science to be a “ticking the boxes” exercise and did not give much consideration to the process. Neither had considered the importance of NoS, or why it was in the curriculum. Joyce was the only teacher to express that she had heard of NoS; to her, NoS was about investigation. This indicated a limited understanding of NoS, as investigation in science is only one aspect of NoS. She stated (section 4.2.2.3) that NoS was “probably” in her planning as “that would be good”, but also advised that she was unconcerned whether students developed NoS skills and understandings. This limited view of NoS as investigation, coupled with unconcern for NoS skills, showed a lack of detailed understanding of NoS and how NoS skills benefit students' learning in science.

Scientific literacy also had no significant meaning to any of the teachers. Holly said that she had never heard of scientific literacy before and had no idea what the term meant. The other three guessed that it was concerned with developing students' vocabulary in science and scientific terminology. They displayed no understanding of its relevance to the NZC or the purpose of science education. This again showed a limited understanding of one of the key goals of the NZC.

The analysis of these findings showed a consistent lack of understanding about the purpose of science education and key component of science education – NoS and scientific literacy.

4.4 Summary of findings and analysis

The findings from the practice questions section of the interviews showed the teachers experienced low levels of training in science education and they had had no in-service professional development in that area. For two of these teachers, it had been over 20 years since their last exposure to science education training. The interviews also found significant limitations in the teachers' abilities to plan for science education. Planning structures were implemented by management, either through a topic or strand per term approach. Most teachers displayed a "ticking the box" attitude towards planning for science, with little or no consideration of the NZC. This section of the interviews also exposed a lack of knowledge regarding current pedagogical approaches to teaching science. The findings showed most teachers used traditional approaches to teaching and learning in science, with attempts to include more current approaches. One teacher used a general (not science-specific) inquiry approach.

The analysis of the practice section of the interviews contributed towards the identification of three of the four themes. The first theme identified was the limited science education training and professional development. None of the teachers had received any professional development in science education.

The second theme identified was the low status of science education in those primary schools. This theme emerged throughout the findings, particularly through the teachers' and the schools' attitudes towards planning for science and being familiar with the science curriculum area. The teachers often spoke about science being a 'tick box' in their planning, with two teachers admitting that they did not consult the NZC when they planned science. The time spent on planning for science reflected the low status given to science education, because the teachers felt it was more important to focus on other areas of the curriculum.

The third theme to emerge was the lack of knowledge about current approaches to teaching and learning science. This theme was identified through the teachers' comments about the way they taught science. Many of the examples given demonstrated traditional approaches to teaching science, although some were mixed with more current approaches. Although some of the teachers attempted to include more current approaches, they lacked a detailed understanding of what these approaches entailed.

The findings from the personal perspectives section of the interviews indicated that the teachers had not really thought about why science was important, why they taught it, or how NoS contributed to science education. Two main ideas emerged as the purpose of science education. They were to teach students about the world and to develop inquiry. Lesser aspects of why science should be taught were discussed, such as developing understandings of scientific principles, and engagement with lessons through hands-on, fun activities. One teacher noted that, for her, science lessons were less about the knowledge and more about developing learning skills for the students.

Responses to the interviews clearly demonstrated that the teachers placed no value on NoS. All of the teachers were unsure about what NoS was, explaining that they did not include NoS in their planning or teaching. One teacher noted that she was unconcerned whether the students achieved NoS goals. None of the teachers knew what scientific literacy was. Three guessed that scientific literacy was the terminology and language of science.

The analysis of the findings in this section showed one major theme – a lack of understanding of the purpose of science education. This significant theme emerged throughout the interviews. The teachers' lack of knowledge about NoS resulted in their limited knowledge about why science was taught and contributed to their traditional views of content-led approaches to teaching science. The teachers were more concerned with students engaging with their lessons rather than students being engaged with science and understanding its nature.

This chapter describes the findings of the interviews and identifies four relevant themes, which have been coded through the process of thematic analysis. Discussion on the significance of these themes, with support from and reference to literature, will follow in the next chapter.

Chapter 5
Discussion, implications and limitations

5.1 Introduction

The previous chapter presented the findings from the interview questions and followed with analysis that identified four significant themes through thematic analysis. These four themes are: limited science training and professional development, low status of science education, lack of knowledge about current teaching approaches, and limited understanding about the purpose of science education. This chapter will discuss these themes and their significance according to the literature review in Chapter 2. Following discussion of the individual themes, this chapter will consider the implications of the research and proposed actions. The chapter will conclude by identifying the limitations of the study.

5.2 Discussion

The discussion in this chapter will relate the themes identified to research and literature previously discussed in Chapter 2. It will explain how this study confirms previous research and literature, and how it has created an opening for further research. It will explain how this study contributes to the field of educational research and elicits new knowledge. The themes will be discussed individually, however, they will be linked by a common thread that became apparent during the analysis of the data. While limited science training and professional development is a theme in its own right, the analysis provided sufficient evidence for the inference that insufficient training and professional development is a contributing factor to the existence of the other three themes. This discussion will identify and explain limited science training and professional development as a theme before demonstrating how it contributes to the other identified themes.

5.2.1 Limited science training and professional development

The theme of limited pre-service training and professional development for in-service teachers in science is not considered new. Bull et al. (2010) identified this trend six years ago, and found that it had existed for years preceding their acknowledgement of it in 2010. They expressed concern about the low levels of pre-service training in science education that teachers were receiving, and this concern extended to the limited professional development or support for in-service teachers, which had been insufficient for many years. This study confirms that the concerns of Bull et al. are valid. These interviews engaged with two teachers who had received their teacher training more than 20 years ago and two beginning teachers who had completed their training less than four years ago. All teachers had a remarkably similar training experience despite being more than 20 years apart. Science training was and still is one compulsory six-week paper (half a semester) at the beginning of the degree. None of these teachers expressed having received any professional development in science education during their careers. This strongly supports Bull et al.'s assertion that there has been limited and insufficient professional development in science education supplied to in-service teachers.

Natalie and Joyce were in-service teachers during the implementation of the 1993 curriculum. Hipkins' (2012) criticism of the lack of direction or explanation regarding the implementation of NoS within this curriculum appears to be warranted, at least with these two teachers. Neither of these teachers indicated that they had received any in-service training explaining the intentions of the 1993 NZC science learning area, in particular the new idea of NoS. The lack of understanding of NoS displayed by Natalie and Joyce appears to stem from the low levels of initial training they received and continues because they have not received (for whatever reason) in-service professional development in science education.

Twenty-three years on from the introduction of the 1993 curriculum and eight years on from the initial implementation of the 2007 NZC, initial teacher training programmes do not appear to be any more in-depth or expansive in the time spent explaining the science curriculum learning area or helping teachers develop abilities in planning and teaching with current pedagogical approaches. Both Holly and Emma reported spending only six weeks in the first semester of their degrees completing one paper in science education. They explained that, while there were other science papers available, they were not compulsory, and neither of these teachers chose to complete them.

International and New Zealand research shows that teachers' skills and professional identities in science are orientated towards traditional views of teaching (Bull, et al., 2010; Hipkins, 2012; Irwin, 2000; Jones & Carter, 2007; Rennie, 2005; Slavin, et al., 2014; Smith & Gunstone, 2009). Furthermore, despite the international call for scientific literacy and changes to educational policy in science, this small-scale NZ study indicates very little change in teachers' practice; students are still receiving a disenchanting and traditional science education, irrelevant to their daily lives (Bull, et al., 2010; Fitzgerald, et al., 2013; Gilbert, 2012; Hume & Coll, 2010; Saunders & Rennie, 2013; Slavin, et al., 2014). This situation in NZ continues because of inadequate science training for both pre-service and in-service teachers. Changes in policy and curriculum mean nothing if they are not accompanied by relevant and sufficient professional development or training (Barker, 2004; Bull, et al., 2010; Hipkins & Barker, 2002). Neither Natalie nor Joyce in this study indicated that they had received any professional development following the changes to curriculum policy in 1993 or in 2007. Both Holly and Emma expressed having very little initial training in the science learning area during their degrees, which were post the 2007 curriculum policy change.

This study indicates that, although policy regarding the NZC has changed to include NoS and has at its heart the notion of scientific literacy, there is a gap between the ideals espoused by the policy-makers and the practices and knowledge of these teachers. This gap may in part have occurred because these teachers did not receive sufficient training in science education.

Extensive literature and research, both internationally and nationally, show that teachers are lacking sufficient training and are receiving little or no support or in-service professional development in science education (Bull, et al., 2010; Hume, 2015; Slavin, 2014). The literature also expresses the negative implications of this lack of training in teaching and learning in science, and students' engagement in science. There is clearly a strong need to train pre-service teachers with sufficient understanding of the curriculum and pedagogical approaches for teaching science to help create a more engaging and beneficial science education for students. There is also a need to provide accessible, on-going professional development and support for in-service teachers to promote understanding of and compliance with policy and curriculum changes.

The limited pre-service training and lack of in-service professional development of the teachers in this study may have affected their ability to plan and teach effectively in science. It would appear that limited pre-service training in science set these teachers up to fail. Such a lack of preparation implies, before their careers have begun, that science is of less importance than other curriculum areas such as numeracy and literacy, which are given more focus throughout their training. Limited time spent learning about the science curriculum means teachers do not get the training they need in order to understand the science learning area of the NZC. It also follows that the teachers' content knowledge and pedagogical approaches for teaching science would be limited. The lack of training prior to their teaching careers also appears to affect teachers' understanding about the purpose of science. These teachers did not have personal philosophies about the importance of science. With so little time spent learning about and being trained in ways to plan for and teach science, these teachers understandably placed a low status on science, and consequently had a low self-efficacy in science. The following discussion will show that limited training in science education results in a reduced capacity to plan and teach science.

5.2.2 Low status of science education

The theme of low status in science education appears to follow a chain of command starting, surprisingly, with government policy in education. The National Administration Guidelines (NAGS) (MoE, 2015c) state that all schools need to develop curriculum policies that promote opportunities for achievement in all curriculum learning areas. The policy then continues to declare that priority for achievement be given to numeracy and literacy, thus stating that numeracy and literacy have a greater importance than all other learning areas in the curriculum. Such policy has also placed pressure on teachers and schools to focus on these two learning areas through the introduction of monitored standards. It undermines achievement in science and seems to go against the policy of the curriculum (Hume, 2015). While it is mandated that all areas of the curriculum be taught, NAGS (2015c) indicate that some areas can be given less consideration or attention. Science is one of these learning areas. This status of lower importance can be seen in the two study schools, Aroha and Moana. Management, who are responsible for ensuring that all areas of the curriculum are implemented within their school, seem to be less concerned with ensuring science is planned and taught in a meaningful way, or even whether it matches the NZC-mandated AOs than other curriculum areas. Both schools appear to have placed a low status on science education judging by the way the teachers reported their implementation of the science curriculum. Aroha Primary incorporated science under a subject area unifying topic, thus integrating the science learning area. This outcome aligns with what Hipkins and Bolstad (2008) suggested would happen due to the higher status placed on numeracy and literacy – other learning areas would become integrated under one subject. This style of curriculum design is mandated by management and is school-wide, which indicates that the status of science education is assigned by management and sustained by the teachers.

Another indicator of low status being ascribed to science education is the reduced amount of time teachers are giving to planning and teaching science. Slavin et al. (2014) predicted this outcome, claiming that due to the policy of monitoring standards, teachers will naturally assign a higher status by way of time, effort and resources to monitored learning areas – numeracy and literacy. All four teachers in this study indicated that they now had less time for science education. Joyce expressly stated that, compared to literacy and numeracy, science was not a priority for her, and was taught in the afternoons if time allowed. The other three teachers indicated that time was a major factor for them, and that they had more important things to do than planning for science. As a result, they tended to use pre-made lessons or units derived either from the internet or from Ministry of Education developed science resource books. These teachers admitted to not using the NZC to assist in planning science, or even to check that the pre-made unit/lesson plans matched the NZC AOs. Holly and Natalie in particular admitted to not being familiar with NoS and the NZC science learning area. They used pre-planned units from resource books that included their own AOs. Natalie felt that this meant she did not need to consult the NZC because everything she needed was in the resource book.

Holly was not actively involved in the science unit planning; rather her syndicate leader made the unit plan for her, using a 'generic, school-wide planner'. It is probable that because this generic planner had not been designed specifically for science, and the planner used by Natalie had not been designed in accordance to the NZC, that elements of science education had been overlooked, such as the inclusion of NoS or ethics in science. However, if both teachers had been provided with adequate training and professional development, it is likely they would be aware of the elements in the NZC that were missing from their planning and teaching. Because these teachers indicated that they lacked understanding about the curriculum area and NoS, the inference can be drawn that they had not received adequate training in this area. Lack of training is a highly probable reason for Holly and Natalie not being familiar with NoS and how it fits in the NZC. Another contributing factor to Holly's lack of understanding of the NZC could be that she had little involvement in the overall unit plan. The planning happened around her, not specifically involving her. Holly was not provided opportunities within her school to develop skills in planning for science, which indicated that the school placed low importance on this area.

The seeming lack of detail in planning and the indicated time and resource restraints resulting in the exclusion of the NZC and the mandated AOs demonstrated the low status of science education in these schools, and reinforced Slavin et al.'s (2014) prediction of unequal time and resources for lower status learning areas. If science held a higher status in the perceptions of teachers and schools, it is reasonable to expect updated resources being created and implemented with current science professional development being mandatory in all schools to ensure up-to-date teaching and planning practices.

To summarise, a major contributing factor to science having a low status is NAGS standards policy (MoE, 2015c). Slavin et al. (2014) and Hipkins and Bolstad (2008) both express concerns about what is happening to science education due to this policy. This study shows that in at least two schools, science has a low status of importance. The consequences of low status found in this study are insufficient attention to planning science and insufficient knowledge of the NZC science learning area. None of the teachers used science-specific planners. The teachers were unfamiliar with the science curriculum learning area, unsure of what NoS was or how it related to the science strands, and they were unconcerned with ensuring the science curriculum and AOs were taught.

Although this is a small study of four teachers, it may suggest that science education is ascribed a low status in other schools in New Zealand. Research and literature suggest that this is indeed a wide-spread issue (Hipkins & Bolstad, 2008; Slavin, et al., 2014). There may be many contributing factors leading to the low status, however, NAGS is clearly an important one. Research should be considered to investigate how science education can overcome undermining policy changes in order to fulfil today's demands for scientifically literate citizens.

5.2.3 Lack of knowledge about current teaching approaches

The literature review in Chapter 2 shows that science education policy has come a long way from the pre-1980s traditional science classrooms. Current teaching approaches include inquiry-based pedagogies, allowing students to experience NoS in an authentic way while learning scientific concepts that relate to their lives (Bull, 2011; Hume, 2015). This authentic interaction with science, both in its nature (NoS) and with concepts, allows students to develop scientific dispositions and reasoning and thinking skills. These skills and dispositions help students to become participating, scientifically literate citizens (Hipkins, 2012). This is essential to sustain a healthy democracy and contribute to the future economic and social development of the country (Bull, et al., 2010). Unfortunately, according to literature and confirmed by this study, teachers are not teaching using current teaching approaches (Bull, et al., 2010; Rennie, 2005; Slavin, et al., 2014). There were various examples in the findings of how the teachers in this study were demonstrating a lack of knowledge about current teaching approaches. While Emma and Holly used terms such as 'inquiry' and 'exploration' to explain their teaching approach, they were unable to explain these terms any further or describe how they used these approaches. This indicates that these teachers did not fully comprehend concepts concerning inquiry learning and teaching and lacked knowledge about facilitating this approach to allow for authentic experiencing and engaging in science for the students. The NZC is written with NoS and inquiry-based learning as central components (Hume, 2015), therefore, it should be expected that pre-service training institutes teach this during the compulsory six-week science paper. If the pre-service training is adequate then all teachers trained after the 2007 NZC should have a detailed knowledge of inquiry learning and how to include NoS in their teaching. It is reasonable to assume that through using inquiry-based approaches, teachers may develop and begin to perfect specific skills and personal approaches in inquiry learning. At the very least, beginning teachers should have adequate knowledge of inquiry learning (through NoS) and why/how it is used.

When questioned about their actual teaching practice, Emma and Holly gave examples of mostly traditional approaches such as having a strong content focus, teacher-led discussions and explanations of concepts, and a large focus on reading and writing (Rennie, 2005; Saunders & Rennie, 2013; Tytler, 2007). Joyce gave an example of teaching scientific investigation skills through the science fair context, developing students' understanding of 'the scientific method'. Speaking about 'the scientific method' seemed to indicate her understanding of a single method of investigation that she was passing on to her students. This demonstrated that Joyce had tried to incorporate the new curriculum (promoting scientific investigation skills through authentic practise) into her traditional teaching practice (using 'the scientific method'). The process of teachers simply including the policy of the curriculum into their already established teaching practice was described by Hipkins (2012) and Donn and Bernie (1992, as cited in Aikin, 1995) and was particularly apparent after the implementation of the 1993 curriculum. This process indicates that teachers did not change their teaching practice to include the new intentions of the curriculum, but rather sought ways to explain how their established practices already met the requirements of the curriculum. This resulted in the continued practice of traditional teaching, especially, as Hipkins (2012) notes, in the area of scientific investigation. Joyce said that she taught 'the scientific method' as 'the way' to investigate in science. To Joyce, this was 'how students understand the scientific method of investigation' (indicating that there is a single method) and she did not appear to recognise any problems with this style of teaching. This showed a clear lack of understanding about NoS and how scientists work and indicated a very traditional approach to teaching and learning science. Without explicit training or professional development in current science pedagogical approaches, teachers will continue to teach as they were taught, creating a cycle of traditional approaches (Bull, et al., 2012) and promoting disenchantment with science in each generation of students.

Research suggests that teachers continue to subscribe to an outdated view of science education and traditional approaches because teachers' existing skills and professional identities are orientated towards traditional views (Bull, et al., 2010; Irwin, 2000; Jones & Carter, 2007). This is because most teachers' own science education was traditionally orientated; this is their experience of science education and they have developed commitments to and identify with traditional approaches (Bull, et al., 2010). It is clear that teachers need a 'new' experience of science education in order to move away from traditional views and approaches. Insufficient training and the lack of on-going professional development for teachers hinders them from making this shift. Teachers need to experience how current approaches to teaching science benefit students' learning and engagement in science. Once teachers have experienced and understood how current inquiry-based approaches build science knowledge and capabilities through the development of NoS, they can begin to change their professional identities and develop skills in this area.

5.2.4 Limited understanding about the purpose of science education

The interviews revealed that these teachers lacked knowledge regarding the purpose of science education – both in understanding the purpose and intentions of the curriculum and in their own philosophy of teaching. Key ideas from the teachers about the purpose of science education related to teaching students about the world and developing questioning. The teachers related the purpose of science to the Living World strand of science, saying that science was about teaching students "how nature works", about "the environment around them" and "how things grow". None of the teachers indicated that the other strands – Material World, Physical World and Planet Earth and Beyond – were a part of the natural world that science concerns itself with (McComas, et al., 2002). This demonstrates a narrow-minded view about what science can teach us and a lack of understanding about the purpose of science according to the NZC. The purpose of teaching science should first be addressed within pre-service training. Then, as policy changes, in-service professional development should be mandatory to ensure all teachers are equipped with the necessary knowledge to teach current science knowledge and skills effectively (Barker, 2004; Bull, et al., 2010). That these teachers struggled to express their own understanding or perspectives on science education or the purposes reflected in the NZC, shows that these teachers were failed by their initial pre-service training and continue to be let down by insufficient professional training.

The curriculum mandates that all science strands be taught with the inclusion of NoS as an overarching, interwoven strand (MoE, 2007a). This way students begin to understand how science knowledge develops and changes over time, how scientists work, and how to question, experiment, communicate and use scientific thinking and reasoning in all areas of the natural world (MoE, 2007a). Teaching NoS within all the other strands enables students to develop conceptual understandings about a range of key scientific concepts that relate to their lives (Bull, et al., 2010). Unfortunately, this study found that none of the teachers were aware of what NoS was and none planned for, or specifically included, NoS in their teaching. Afonso and Gilbert (2010) explain that there is a widespread weakness in the understanding of NoS in students, pre-service teachers and in-service teachers. Some research suggests that teachers lack understanding of NoS because their own education in science did not include a NoS component (Hipkins, 2012). Teachers are unable to identify or envision how NoS ‘fits in’ to their teaching of the strand because they have never experienced NoS themselves. As Bull et al. (2010) explained, they teach according to their own experiences. It appears the teachers in this study did not experience NoS components in their personal science education or in their teacher training or in professional development, as evidenced by their limited understanding of the concept of NoS. They also expressed a lack of understanding of the science learning area in the NZC.

The NZC outlines four main purposes for which science should be taught in schools (Bull, et al., 2010; MoE, 2007a). Bull et al. explain these four purposes to be: pre-professional training, utilitarian purpose, democratic/citizen purpose and cultural/intellectual purpose (section 2.3.2). Teaching NoS supports all four of these purposes (Bull, et al., 2010). It is because these teachers did not teach NoS and were unaware of what NoS was that they were not teaching for any of these purposes. The purpose they came the closest to describing was the utilitarian purpose, stating that science education was teaching students “about the world”. However, this neglects exploration of everyday phenomena and developing practical, relevant knowledge (Bull, et al., 2010). Holly did mention future careers as a purpose for science education, but her main understanding was to teach the students about the world. But if the most important aspect of teaching science is content (teaching students about the world), then many teachers would feel overwhelmed with the responsibility of needing to know about all these scientific concepts themselves before teaching them. However, if teachers see science education as being more about developing scientific dispositions in students (the intention of NoS), then their job becomes less daunting because the focus for teaching shifts from content (knowing everything) to scientific skills (developing scientifically-literate citizens).

The study found that none of the teachers received high levels of pre-service training or any professional development in science teaching, which contributed to their lack of understanding about the science curriculum area. One teacher, Natalie, expressly stated the reason she was unfamiliar with the NZC was that she had not received professional development in science. Natalie had not become familiar with the learning area in 23 years of teaching because she was expecting professional development to assist her with this.

Another possibility for these teachers lacking knowledge about the science curriculum purpose and intent could be that the curriculum fails to provide an in-depth explanation of what NoS is and how it is intended to be taught. A detailed explanation might help teachers who, for whatever reason, are unfamiliar with the concept of NoS, by outlining its importance and how to include it in their teaching. Likewise, the curriculum fails to specifically mention scientific literacy, even though the promotion of attributes reflecting scientific literacy lies at the heart of the NZC (Hume, 2015). Many researchers concur that education for scientific literacy strongly promotes development of NoS (Afonso & Gilbert, 2010; Lederman, 2007). If the goal for science education is to produce scientifically-literate citizens (Bull, et al., 2010; Bybee, 2015; Hipkins, 2012; Hume, 2015; Milne, 2007; Rennie, 2005), then the importance of the development of NoS in the process of such citizenship should be expressly stated in the curriculum. The research found that none of these teachers had ever heard of the term scientific literacy before. This is worrying, especially as Hume (2015) claims that scientific literacy lies at the heart of the science curriculum and the science curriculum statement strongly promotes attributes and dispositions that reflect the nature of scientific literacy (MoE, 2007a). To attempt to mitigate this deficiency in the NZC, the curriculum should expressly state in detail what NoS is, how it should be taught, and its goal of scientific literacy. Teachers lacking training in the NZC science area will at least have clear instruction in the document itself.

This study clearly shows a discrepancy between 'best practice' described in research and these teachers' actual practice. It appears that this can be attributed in most part to limited training and professional development in science (Bull, et al., 2010). However, there may be other factors limiting teachers' knowledge and understanding of the purpose of science education. Literature has identified that the theme, lack of understanding the purpose of science education, particularly NoS, is not new and is of international concern (Afonso & Gilbert, 2010; Slavin, et al., 2014).

5.3 Summary of discussion

The analysis of this study identified a limited knowledge of science education in general in these teachers. This was made clear by the emergence of several specific themes. The first theme – limited training and professional development available in science education – was identified when the teachers disclosed that the only compulsory aspect of science during their teacher training was one six-week paper and that none of them had ever received in-service professional development in science. Literature indicates that this theme is nothing new, with researchers expressing concerns that the low level of training for pre-service teachers and the lack of professional development for in-service teachers has continued for many years (Bull, et al., 2010). A major concern is that policy or curriculum change has very little impact if not accompanied by professional development (Barker, 2004; Bull, et al., 2010; Hipkins & Barker, 2002). This was evident in this study.

The second theme is the low status ascribed to science education. This emerged due to a number of factors: limited or no thought in planning for science, no use of a specific science planner, little reference to the NZC, and limited attention to and appreciation for science education. The findings showed that the teachers considered they had more important learning areas needing their time and resources, so planning in science had more of a “tick the box” approach. Slavin et al. (2014) and Hipkins and Bolstad (2008) attribute this low status to NAGS (MoE, 2015c) educational policies, which assign priority to particular curriculum learning areas.

The third theme that emerged was a lack of knowledge about current teaching approaches in science. The teachers employed mostly traditional teaching approaches in their described practices and lacked detailed knowledge regarding current approaches to teaching science. Research suggests the cause of this to be teachers’ low levels of self-efficacy and their professional skills and identities being orientated towards traditional teaching approaches (Bull, et al., 2010; Irwin, 2000; Jones & Carter, 2007; Slavin, et al., 2014). Teachers naturally teach as they were taught.

The final theme to emerge was a limited understanding of or appreciation for the purpose of science education. The NZC outlines four key purposes for teaching science (Bull, et al., 2010; MoE, 2007a) and none of the teachers had a detailed understanding of any of these. The study found these teachers had a limited knowledge of the science curriculum area, no knowledge of NoS or scientific literacy, and no clear purpose for why they taught science. Possible arguments for this lack of understanding about the NZC could be related to teachers’ initial training in science and lack of on-going professional development in the area, as was indicated by Natalie. However, the NZC also does not state specifically what NoS is and how and why it is to be taught, nor does it use the term ‘scientific literacy’ or give explanation as to what it is (Hume, 2015). This could also be a contributing factor as to why teachers are unsure of these two critical terms. Given the importance of NoS and scientific literacy to sustaining a healthy democracy and contributing to future economic and social growth (Bull et al., 2010), a detailed explanation of its importance and how it should be taught should be included in the document that is promoting it – the NZC.

There were four clearly identified themes analysed from the findings. Through the analysis there emerged an underlying link between the first theme – limited science training and professional development – and the other three – low status, lack of knowledge of current teaching approaches and limited understanding about the purpose of science education. The next section, will clarify how the first theme appears to sustain the other themes. It will specify the implications identified in this study and suggest possible solutions or areas for further study.

5.4 Implications of this study

This study suggests science education has been ascribed a low status by government policy, schools and teachers. It also identifies a lack of understanding and knowledge in the teachers involved about current pedagogical approaches and the purpose of science education, science in the NZC, and NoS. These findings indicate a detrimental lack of pre-service training and professional development in science education. It became apparent through the analysis phase of this study that this theme – the lack of training and professional development – formed the basis of the other three themes. Insufficient pre-service and in-service training is largely responsible for the other three themes.

Because science training is limited to a six-week paper, teachers gain the impression that science is not as important as other areas of the curriculum, such as numeracy and literacy, which are given extensive coverage throughout the degree. This initiates the assignment of low status to science education during pre-service training. This attribution of low status is then reinforced once the teachers begin their careers by current government and school policies, which give priority to literacy and numeracy. In order for teachers to develop positive attitudes towards science teaching and planning, teachers need to experience science as an integral part of the NZC. This must happen from their pre-service training and continue throughout their teaching careers.

This study shows these teachers are lacking knowledge regarding current approaches in science education. Evidence would suggest that there has been some exposure to current teaching approaches because the teachers referenced key terms such as ‘inquiry’, ‘exploration’ and ‘life-long learners’. However, this exposure has not been sufficient for these teachers to fully comprehend what these terms mean and the reality behind them, and how to effectively incorporate them into their planning and teaching. It can be assumed that the exposure to current approaches was during initial teacher training because none of these teachers have received in-service professional development. This presents a clear need for assessment in the competency of teacher training programmes and a pressing need for in-service professional development in science education.

The teachers lacked the ability to describe what the purpose of science was, either according to the NZC or their own personal beliefs. They were unable to explain the curriculum learning area and had very limited knowledge of NoS and its intentions. Understanding why science is taught and understanding the science curriculum and its key components should be key considerations for teacher training. However, according to this study, they are not, or such training is ineffective. The question must be asked, what are pre-service training institutions teaching in their science programmes if teachers are beginning their careers with limited understandings about current pedagogical approaches and a clear lack of knowledge about science, the NZC and NoS?

The finding of a lack of knowledge of science education in these teachers implies a deficiency in pre-service science training and subsequent professional development. Despite the limited scale of this study, this finding is supported by the literature and must be of concern. Therefore, further investigation should be undertaken to ascertain whether it is restricted only to the schools involved in this research or whether the issue is more widespread.

Once large-scale research has been commissioned and if the issues are found to extend throughout New Zealand, then further research could be conducted into initial teacher training programmes to see if the root of the problem lies there. This could result in improved initial teacher training programmes, resulting in student teachers gaining a meaningful and in-depth understanding of the science learning area, particularly the purposes of teaching science and how science should be taught to achieve those goals. The findings of this research provide a base for such future research.

Continued research in this area could have implications for government education policy-makers, initial teacher training institutions, such as universities, and providers of in-service professional development. For example, policy-makers may need to reconsider policy in light of the effect the promotion of some subject areas over others. They also may need to consider how teachers could be best supported to have a full understanding of the purpose of science education. This may mean professional development on a large scale and such a project would require adequate time, support, resources and funding. Training institutions may need to reassess their training methods and time allocations to various areas. Professional development providers could explore effective pedagogy and tools for inspiring and immersing teachers in science education.

5.5 Limitations of this study

This study has some obvious limitations. The data provided came from only four teachers, across two schools. The small number of teachers involved was due to difficulties in finding participants willing to give their time to be interviewed. The findings from the study are limited in application to those teachers and those schools. Due to the small scale of the study, the findings cannot be used to generalise (Menter, et al., 2011) or conclude that they apply to all or even many schools in New Zealand.

Another limitation associated with the small scale of this study was the lack of additional data-gathering methods to triangulate this data. By using two or more methods of data-gathering, and comparing the results, the researcher can have more confidence that the results are reliable and valid (Cohen, et al., 2011). Observation of teaching practice and analysis of teachers' planning would have provided two additional points of data that could have been used to support the findings of the interview. Unfortunately due to the time and focus restrictions of this research, only one method of data-gathering could be used. The method chosen was interviewing the participants. The interviews provided insight into the teachers' thoughts, understandings and practices at that particular point in time. It is, therefore, possible that the interviews did not capture a full or complete picture of these teachers' perspectives on science education. It is acknowledged that interviews are also highly subjective and so are susceptible to bias (Bell & Waters, 2014). The results have been interpreted by the researcher based on information, both verbal and nonverbal, provided during the interviews. Every effort has been made to reduce the risk of 'researcher bias' affecting the interpretation (Cohen, et al., 2011).

It is also acknowledged that this research was conducted by a first-time researcher. However, the researcher was conscious of the risk of personal bias and attempted, as far as possible, to ensure reliable and valid data was gathered and that the analysis performed with limited opportunities for bias.

Chapter 6
Research summary and conclusion

6.1 Summary of research project

The literature review showed the development of international science education since the reforms of the 1980s, concluding with current views on purpose and practice. Two important matters stood out in the review.

Firstly, the current goal of science education is internationally recognised as being scientific literacy (Bull, et al., 2010; Hume, 2015; Milne, 2007). The global demand for scientifically-literate citizens has emphasised the development of NoS (Afonso & Gilbert, 2010). NoS is a critical component of science education because it is through the development of NoS knowledge and skills that scientific literacy is realised (Lederman, 2007). The NZC has acknowledged the importance of developing NoS skills and knowledge by including NoS as the overarching strand within the science curriculum. The intent is that NoS is taught within the other strands of the science learning area and in this way the goal of scientific literacy will be realised (Hume, 2015; MoE, 2007).

Secondly, teachers are not teaching according to the current goal of science education, nor to the intentions of the NZC. Research shows a mismatch between current policy and practice (Hipkins, et al., 2002; Hume & Coll, 2010; Jones & Baker, 2005). Research has made suggestions as to why teachers are enacting their own curricula, implying that teachers know about current purposes and practices of science education and are choosing to ignore them for various reasons. These reasons related to: teachers' own experience of science education and their tendency to teach as they were taught (Bull, et al., 2010; Irwin, 2000; Jones & Carter, 2007), low self-efficacy and confidence in teaching science (Slavin, et al., 2014; Tytler, et al., 2008), lack of training or in-service professional development around NoS and teaching approaches (Afonso & Gilbert, 2010; Hipkins, 2012), and other possible educational policies that may be causing teachers to ignore the NZC, such as the NAGS standards policy (Hipkins & Bolstad, 2008; Slavin, et al., 2014). This discovery of a mismatch between policy and practice generated the question – do teachers *actually* know about current purposes and practices or is there a gap between research, policy and practice. Are the research and policy changes being disseminated to current teachers? This study evolved from this question, and developed the question into what do teachers consider is the purpose of science education? This research aimed to discover where the true mismatch lay. Was it due to teachers' unwillingness to change their practice, or was it due to inadequate training and professional development resulting in teachers being unaware of research or policy change?

The research was guided by an interpretive paradigm. Semi-structured interviews were chosen as the best way to elicit in-depth perspectives and understandings due to their flexible nature and because there was to be only one source of data collection (DiCicco-Bloom & Crabtree, 2006). The data collection method obtained qualitative data, descriptions and words, and needed to be flexible to pursue and explore responses when necessary (DiCicco-Bloom & Crabtree, 2006; Gill, et al., 2008; Menter, et al., 2011). The interpretive paradigm also guided the approach to data analysis. Thematic analysis was chosen because it was a qualitative approach to coding themes and allowed for the interpretation and speculation of those themes (Braun & Clarke, 2006; Mutch, 2005).

The findings of this study support the claims made in literature that, in New Zealand schools, teachers are using their own enacted curriculum. The disparity found between the policy of the NZC and teachers' practice in planning and teaching science showed evidence of enacted curricula. Perhaps the most significant factor contributing to the use of an enacted curriculum, in this study, was the low levels of pre-service training and on-going, in-service professional development. The findings from this study provided evidence for the conclusion that these teachers used an enacted curriculum due to limited training in science education and no professional development accompanying policy changes, such as the implementation of curriculum documents. The findings reflected a consistent lack of knowledge about current approaches and planning for teaching science. The teachers demonstrated limited knowledge about science policy, particularly in the NZC science learning area. This included fundamental failings in knowledge of what NoS is and why it is important and resulted in admissions that NoS was not taught or planned for. There was also a substantial lack of knowledge regarding the purpose of science. None of the teachers was aware of policy around the purpose of science, even those outlined in the NZC, and none had ever heard of scientific literacy. What was more worrying is that these teachers did not even have personal philosophies about science education. The findings showed that these teachers struggled to answer the key question behind this study – "What is your understanding of the purpose of science education?" The teachers lacked any substantial understanding of the purpose of science education.

The findings of the study were coded into common themes: limited science training and professional development, low status of science education, lack of knowledge about current teaching approaches, and limited understanding about the purpose of science education. These themes are discussed and described, with evidence from the interviews to support their interpretation. While they were all established themes in their own right, it became apparent during the analysis of the findings that one theme – limited science education training and professional development – was an underlying cause of the other three.

The implications of these findings include showing a vital need for adequate training in science education to address the issue of the mandated curriculum being displaced by an enacted curriculum, and to ensure students are receiving a positive, engaging and current science education. Further research may verify whether the problem of an enacted curriculum is due to a lack of training across schools in New Zealand. The results of further research could impact on government policy-makers, teacher training institutions, such as universities and schools, and professional development administrators.

This study has clear limitations due to being small in scale. The findings are, therefore, only a small insight into teaching practice and knowledge in science education in two New Zealand schools. In addition, due to the scale and the time limitations imposed by the participants, only one method of data collection was used. This is a significant limitation because it did not provide opportunity for triangulation of the data.

Notwithstanding the limitations of this study, the findings are supported by the literature. This suggests that they may have a wider application, but caution must be exercised in such an application.

6.2 Concluding comments

This study sought to answer four main questions: What do current primary teachers believe to be the purpose of science education? What understanding do current primary teachers have of scientific literacy and what role do they believe scientific literacy plays in science education? What does the Nature of Science mean to current primary teachers, and what do they believe is the purpose of teaching NoS? How do current primary teachers include NoS in their planning and teaching? The research found that the teachers had scant understanding of the purpose of science education. They had little to no idea of scientific literacy and how it derived from science education. Although some of the teachers had heard about NoS, there was no clear understanding of this crucial strand in the NZC, therefore, they did not include it in their teaching (though it may have appeared in ‘tick boxes’ on their planners).

This lack of understanding about science education demonstrates a clear mismatch between educational policy (the science curriculum) and science teaching practice (the enacted curriculum). There were several contributing factors to this mismatch, and this study found that for these teachers there was one underlying component found in all the identified themes. These teachers lacked sufficient training in science education. This conclusion implies a need to inquire into current teacher training programmes and to ensure accessible, relevant and on-going professional development programmes are available. Further research is needed to establish whether there is an issue of low level science education training across the nation. If further, broader, research finds this is not the case in other schools then research is needed to ascertain why the enacted curriculum, claimed by Hipkins et al. (2002), Hume and Coll (2010) and Jones and Baker (2005), exists.

In today’s society, the call for scientifically-literate citizens is more strident than ever for sustaining a healthy democracy and the development of economic and social growth (Bull, et al., 2010). Unfortunately this call is seemingly being ignored or overridden by the competing call for improved literacy and numeracy, as this study suggests. The development of NoS skills is a high priority in science education since it establishes the attributes needed to produce scientifically-literate citizens (Lederman, 2007). As a result of these teachers’ lack of awareness of the purpose of science education and the curriculum learning area, NoS skills and knowledge were not being developed and taught in these schools. Research suggests that these issues are not only present in the participating schools but are found worldwide (Afonso & Gilbert, 2010; Rennie, 2005; Saunders & Rennie, 2013).

To achieve the goal of producing scientifically-literate citizens, teachers need to be guiding students to understand and appreciate NoS as intended by the NZC. If they do this, students will develop the skills and attributes necessary to enable them to participate as informed citizens, capable of making decisions about and participating effectively in science-related issues that affect all of our lives (Milne, 2007). Teachers cannot do this if they themselves lack a proper understanding of science education, including its purpose, the relevance of NoS, and the current approaches to teaching practice. This issue can only be addressed by improving the training in science education provided to teachers, both pre-service and in-service.

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APPENDIX 1
Interview Questions

Interview questions:

1. **A)** When did you complete your teaching degree?
   B) How long have you been teaching?

2. **A)** Was science (any type of science papers) part of your initial teacher training?
   B) Was science compulsory?

3. **A)** What is your understanding of the purpose of science education?
   B) Why teach it?
   C) What do you want your students to get out of your science lessons?

4. Who decides what topics/concepts/skills will be taught and when (when will they be taught and when do you/other decide upon topics etc)?

5. Are there any particular pedagogical approaches you use when teaching science?

6. Are there any particular planners/planning approaches you use?

7. **A)** What does the Nature of Science mean to you?
   B) How do you include it in your teaching/planning?

8. **A)** Have you ever heard of scientific literacy?
   B) What does it mean to you?
   C) How do you teach/plan with/for scientific literacy?

9. Do you find the NZC layout/design for science helpful? Is it easy to follow/understand? Do you understand what/how you are required to teach science education from the NZC?

APPENDIX 2
Holly's Transcript

R: So when did you complete your degree?
H: 2014. This is my first year teaching.
R: And you are doing year...
H: year 3 and 4.
R: Okay, so where did you do your degree
H: Waikato.
R So was science any part of your initial teacher training?
H: Only that one science paper we did in first year… I think it was half a paper…. About 6 weeks.
R: So you had 6 weeks of science education during your degree and that was it?
H: yeah.
R: and that was in your first year wasn't it?
H: yeah, that was in 2011 because I had a year off after my first year and then came back to the degree.

R: So what is your understanding of the purpose of science education? Why do you teach it?
H: I suppose it links to many professions later on in life and it is a grounding for what's going on around the students. It's important for them to understand how things around them work, grow. Just how nature works. And also opens them up to ask their own questions about things. It gives them an inquisitive mind if you give them the option of looking into things that excite them.
R: So gets them to think about what they are interested in?
H: yes and like inquiry. Use it a lot in getting them to come up with things. Like what do they know about something, what are they going to know?

R: What you want your students to get out of a science lesson?
H: learn something new. Cement what they already know. And feel confident to share what we've learnt. And also to get them to question more than what I've already taught them. Like get them to go away on their own and sort of come up with more things they want to do, not just what I give them.
R: So kind of get them engaged and excited about the topic that they themselves investigate it?
H: yeah.

R: Who decides what topics/skills/concepts will be taught and when?
H: at this school?
R: Yes.
H: we have an overall theme or curriculum area that we are focusing on school wide. For example we are all focusing on let's say social studies or science each terms and each syndicate can take it their own way
R: so you just get told you are doing social studies?
H: yes

R: and you can choose any area of social studies?
H: umm, well maybe it will be like ‘building relationship’ which is in social studies and then everyone will take it in their own way. Each syndicate. But at the moment we are actually doing a science focus this term. It was decided school wide to do it. And actually I think all of the syndicates are doing living world. So that was pre-decided. It was decided by management basically. We don’t really have a choice.
R: so what gets taught it not really up to you as a teacher?
H: I can only speak for my own syndicate, but we would do an overall unit plan together and our syndicate leader has a big influence on that. She actually writes up the unit. So she might changes things. And then from there we can teach it however we want to kind of meet those criteria we’ve come up with.
R: You’re given the concepts skills and topics to be taught, but you decide how you are going to do that?
H: yeah
R: Do you also get to decide the context for the learning? Or is that also given to you?
H: yes we come up with that ourselves. But saying that I work closely with my mentor teacher and we often plan and things together. So from our syndicate meeting we often go and plan something. Then of course we do spin it ourselves in our different classrooms.
R: right. So you find the planning quite structured?
H: yes
R: and do you like that approach?
H: I do, as a beginning teacher. I think it’s much more structured and it’s easier for us to handle it as beginning teachers who don’t have that experience yet. Especially with having so little PD in it, how are you supposed to.

R: are there any particular pedagogical approaches you use when teaching science?
H: You’ll have to be more specific sorry
R: is there always a particular way you would approach a science lesson? Is there a pedagogical approach that you tend to use a lot?
H: we always start with a hook to engage the students. Is that what you mean?
R: yeah, go on
H: that’s usually syndicate wide, we use a hook to engage for the whole unit and then for each lesson from there we do the usual thing of sharing our learning intentions, having an individual hook in the classrooms and then posing what they know about the lesson and then giving them a chance to explore it themselves first, before I tell them a whole lot of stuff or we do activities. I first want to know what they know already. Then we start with like the whole class and then often we go down to pairs or buddy work and then individual activities to see if they actually get it. We do pre and post assessments. Is this what you are looking for? I’m not sure.

R: Are there any particular planners that you use?
H: well we have a generic unit planner, and that’s syndicate wide, obviously. And then from there we may create our own lesson plans… if you want to call it that. Kind of outlining each lesson.

So for example, we are doing living world at the moment and we have our overall unit plan. But I've broken it down into lesson one, is finding out what's living and non-living. Lesson 2 is finding out the role of bees. Lesson 3 pollination. And I do it like that.
R: and you make those lesson plans yourself?
H: Yeah, yeah

R: What does the nature of science mean to you?
H: oh my word. What does that mean?
R: so, the nature of science in the curriculum, the overarching strand. What does that mean to you? Why is it in there?
H: I guess it kind of links to one of the questions we had before. It's around the children and they need to understand the world the live in and how things work…. I have no idea.
R: So do you plan for teaching the nature of science at all in either the lesson plans or unit plans?
H: I don't know if it's included in the unit plan. I actually don't know. I couldn't tell you.
R: So when you do your lesson planning do you look at the nature of science strand?
H: it's more that I look at the strand [that's being taught]. It's very specific.
R: so you wouldn't say that you specifically teach NoS?
H: no. we have a theme that we teach. Like electricity.
R: But within that theme, do you teach or allow for exploration of NoS?
H: I don't actually understand what you are asking to tell you the truth. So obviously not, because if I don't know what you are talking about then I obviously don't do it.

R: Have you ever heard of scientific literacy?
H: no.

R: the next question is what does it mean to you. Do you want to answer it?
H: um like researching. Students doing research on science concepts? I'm not sure. Sorry, that's probably not good or helpful.

R: how would you plan to teach for scientific literacy?
H: I don't know.

R: Okay last question, do you find the NZC layout helpful for teaching science? Is it easy to follow and understand?
H: I think it's a little bit too open. We do use, I don't know the names of them, but little green books. We use those a lot to try and help and bridge the gaps in the curriculum. But as I said I plan in a syndicate so I am with a lot of experienced teaches and so that helps me a lot obviously.

APPENDIX 3
Natalie's transcript

R: When did you complete your teaching degree?
N: I've been teaching for 23 years so a while ago. It was 1992.
R: what kind of age groups?
N: new entrant to year 3 I've taught
R: for the whole 23 years you've done those ages groups?
N: yes. I enjoy it. I was an early childhood teacher before I went to teachers collage so yeah I enjoy it.

R: During your degree was science part of the initial teacher training?
N: yes it was, the curriculum science. Because I did a diploma, there was the curriculum science but in my degree I did some science as well.
R: so in your diploma was it compulsory to do science?
N: yes, all curriculum areas were.
R: so with your degree it was also compulsory?
N: no, it was a choice. So I chose to do biology and a bit of chemistry. But I took biology further on.
R: What was your degree in?
N: in Education. When I was at teachers college, our diploma and our degree went side by side and we did the whole thing over 4 years.
R: oh okay. So your diploma was in teaching and your degree in education?
N: yes.

R: So what is your understanding of the purpose of science education? Why do you teach it?
N: Well because it is part of the curriculum of course, but also because it allows you to give the children a bit of an understanding of the world and how the world works and the why of things and also it answers lots of 'I wonders'. Yeah I think just to add more experience to their little lives more than anything.
R: what do you mean by 'experience to their lives'?
N: well children are naturally inquisitive, and to use that inquisitive nature is actually going to bring them a step further in their lives. Like when it comes to vocab enrichment and just understanding the why of things. And also it gives you the opportunity to encourage independent learning. That wanting to find the answer to things and wanting to set up challenges and work through things and not always accepting other people's answers, but gives them a chance to think about things.

R: What would you want your students to get out of your science lessons?
N: I think the biggest thing is, not necessarily the knowledge, but the skills and the strategies of discovering new things. So I'd like them to think 'if this is the case for this, I wonder why it works with this'. So encourages them to be a bit more self-directed in their learning. I think all the way through, science is not just 'in the science time', like 'now we are going to do science' - in the junior school I'm thinking. Because it's a daily, all the time type of subject. Because it's what's around us and it's how we, how our world works. So

there are opportunities right throughout the day to be talking about things that are science. So that may be why children don't always know that they're learning science because it's integrated throughout the day. For example we are doing living world at the moment, because our school runs that every term we focus on a different part of science. So this term is a living world unit. Just outside my classroom we have a bunch of willow trees that have been cut down and the stumps have been placed in the playground amongst the bark. And all of a sudden these shoots have started coming out of these stumps and I wonder why. If the shoots are coming out, does that mean these stumps have grown new roots? So I'm modelling that all the time, while I'm on duty I'm out there talking to the children [about this].

R: that has kind of lead us on to the next question which is who decides what topics, concepts and skills will be taught and when? Now you've said that each term is a new strand, is that correct?
N: Mm. every school from what I can see does it in a different way. I know that in my last school many years ago we have even years and odd years on what topics we had to do. Now, although we have a strand of science that we cover each term, the teachers can choose what topic or unit you are going to do within the strand. So as a syndicate, because we do our inquiry planning together, we decide as a syndicate what we are going to do.
R: So say the strand is living world, as a syndicate you would choose….
N: its more the objective that we choose together and then we try and get a unit that's going to fit with that objective. So even though we might be doing living world there will be one certain AO that we need to cover. So as a team we decide how we are going to cover that AO. So because we know what we've done in the past we can think of a different, more exciting way to do it this time.
R: so you choose the AO and then what context?
N: yes, and the skills and strategies that we want as well.
R: so as a junior syndicate would you all teach the same unit? Or context?
N: sometimes we do, sometimes we do it pretty well identical, but depends where your class will take you. But sometimes we think we might have a personal interest or something has come up in the classroom so we decide to do our own thing. But usually the syndicate does the same thing. But that's not to say that just because the whole school will do living world, I can't say 'something really cool is going on, on my science table at the moment' or magnets or something like that. I can put all that stuff in there as well. I think that's the wonderful thing about being a New Zealand teacher, we have the freedom to follow the class interest.
R: okay, so you do at least one science strand per term
N: yes, at least.

R: are there any particular pedagogical approaches you use when teaching science?
N: well its inquiry based. So starting with what the children already know and getting them sort of bombarded with lots of things that are going to motivate them and intrigue them in the beginning. And then going from their own questions. And that directs usually exactly where we want to go with the unit. We have an overall, overarching big idea that we need

to get to. But we allow the kids to direct how we get there. So even though we do a syndicate, plan a unit together, each classroom might have a little bit of a spin on it because it will depend on the children's interest and what they bring up in their discussions. And I think probably too with what's available now, compared to years ago when I'd teach science, in regards to digital technology, that's driving us in different directions as well. Because the knowledge is there at the finger tips so it's not so much about the knowledge at the end, but how we get there. It's the inquiring mind and working with, 'here's a challenge how can we solve it?' So giving them the skills to be independent life-long learners.

R: are there any particular planners or planning approaches that you use?
N: we use the source model at the moment. But we have trialled a few different models over the years.
R: you haven't used any standardised approaches? Like the 5 E's approach?
N: no.

R: what does the nature of science mean to you?
N: how do you mean?
R: well in the curriculum we have NoS as the overarching strand, so what does that mean to you? Why is it there? Is it important? Do you explicitly teach it?
N: I'm not 100 percent sure to tell the honest truth. No. I mean, I'd say that it comes under what we do on a daily basis, but I actually must admit I don't look into to make sure that we're doing that part of the curriculum document as such.
R: so it's not explicitly taught or planned for?
N: no. It's probably in our science units, if I had a look I'm sure it'd be mentioned but it's not something I refer to all the time.
R: So you wouldn't look at any of the AOs and choose which ones to be focusing on?
N: no.
R: Okay, so then if I asked how do you include it in your planning… it's not specially planned for?
N: To tell the truth I'd have to have a look at my planning assessment book that's in my classroom. Because I'm sure that…. because we have taken it all from the different things that are in the curriculum, but I can't remember…. Quite often, it's just put there on paper. We know we have our big idea that we are going towards, and then we just tick the boxes for the other things in the planning.

R: have you ever heard of scientific literacy?
N: ummm no more than when it comes to math literacy – making sure they have all that vocab in place.
R: okay so my next question is what does it [scientific literacy] mean to you…. Would that be vocab?
N: yeah.
R: and how do you teach/ plan for it?
N: well just putting it into the context of our units.

R: do you find the NZC layout helpful? Is it easy to follow/understand? Do you feel you know what you are required to teach?

N: I haven't really looked at it in great detail because, with a lot of curriculum documents you end up looking at them in great detail when they end up becoming professional development with the whole school. And so science hasn't come up as a professional development with the school as such. So then it's up to individual teachers to get to know that document really really well. And so because as a time saver, I know the documents there, but it's got a whole lot of other books that go along with it. We end up going into the books to get the AOs that are there. So you tend to find you end up doing it the easiest and quickest way that you can. And there are a lot of resources that go along with the curriculum document. So really, you find that you aren't really looking at the curriculum, we are directed by what the kids are doing and those other documents which are probably a little bit more user friendly.

R: so when you say 'more user friendly' are you finding the curriculum not user friendly?

N: well we use these little books, [primary connections] that have it all there for you. So a lot of it is done for you pretty much. But they are all developed by the Ministry of Education so they've got to match, you'd think. Since the demand on your time is so huge, you just tend to grab these things because it's all there for you.

APPENDIX 4
Emma's Transcript

R: You completed your degree in 2012. Been teaching 3 years?
E: *Nods*
R: All three years in this school?
E: No.
R: What other schools?
E: One in Foxton
R: Okay, What age level was that?
E: Year 5 and 6
R: And that was for how long?
E: 2 years
R: So you have just been here for this year?
E: Yep
R: And this year you are doing?
E: Year 2 and 3
R: Wow, a bit different
E: Yeah I know

R: Okay so going back to your degree, was science or any type of science papers part of your initial teacher training?
E: Yes
R: So how many papers did you do?
E: Umm trying to remember I think 1 or 2. There is one compulsory paper
R: Yeah, so just the one compulsory? Did you do any optional?
E: No because it clashed
R: But you did have the options?
E: Yes.
R: And that would have been in your first year?
E: Yes.
R: Cool, so that meant that there was two years of no science before you finished your degree?
E: Yes.

R: So what is your understanding of the purpose of science education?
E: Umm, to teach students about the world, how everything works, ways you can improve things, ummm, having a look at different, I guess, ways of doing things, ummm, really understanding about where they are from, their environment. All that lovely jazz.
R: Cool, okay what you are saying there, just to clarify, is basically just understanding what happens around them, every day, in the world?
E: Yep, with ya.
R: So that is your purpose of science education – is to teach the kids about the world around them?
E: Uhuh.

R: So the way the NZC is set out, with the living world and physical world and all the different strands, you teach science slightly differently here I've been told? Would you say that you cover all those strands?
E: Yes. We make sure we do. That's one thing we try look into if we haven't. We have just done our overview for next year and there's one, I can't remember which one it is, we haven't touched on this year but it's our first thing to do term one next year to make sure we have our coverage.
R: Okay, so as the kids move through their years at school, you might not cover it all in one year but would you say they would experience each strand as they move through the school?
E: Yes. They would.

R: Just thinking about your science lessons – I know it's a bit different because you teach science as cross-curricula within your enviroschool topics, But what is it you want the kids to get out of each individual science lesson? So your overall purpose is to teach them about the world around them. With the individual lessons, what is it you want them to get out of learning science in your classroom?
E: Fun and enjoyment, umm, being able to understand content knowledge as well as umm I guess just being able to explore and experiment, kind of develop a new understanding in a way that they can understand so that things makes sense to them. If that makes sense?
R: Yeah it does.
E: Umm well yeah that's my intention
R: Would you see science as an individual or a community exercise?
E: Both
R: Could you expand on that?
E: Umm I think obviously individually because there are things that umm individual kids need to work on more than what they do as a whole group or as a whole school. So individually do you mean one person or say a class rather than a big group?
R: So, the concept of science, would you see it more of an individual exercise where one person sits down and works out physics or what not, or a combination of people's ideas working together? So would you expect the kids in your class to do individual science learning or is it more of a collaboration, group task?
E: Umm more of a collaboration, group task. Mainly because its easiest way to teach, and kids like working together. Umm but then you do have students who like to work by themselves and find it easier to work by themselves, they understand things better if they are by themselves. Umm but I would prefer my students to work in a group. So they can bounce ideas and look at things from other people's perspectives, not just their own.
R: Alright, so you are big on them exploring their own and each other's ideas?
E: Yes, definitely, to me that's what it's all about.

R: Okay so who decides what topics, concepts, skills will be taught and when?
E: Um the whole staff, and that's usually at the beginning of the term. We have like a planning day where we sit down and discuss what our topic is going to be for the term and what strands we can fit in and how we are going to teach them and just throwing ideas around on the table really.

R: So you've just done water haven't you?
E: Yeah we are doing water now.
R: So what kind of science strands are coming in under water?
E: Oh gosh, there's no curriculum [to look at]. Umm I don't know
R: Okay, well do you focus on a specific strand or are there a few?
E: Try fit in a few, yeah, if we can. For us water [has been] over two terms so as much as we can fit in the better and that's only because our massive enviro school presentation that is on Thursday, is on water. So that's why it's had to run for so long.
R: Okay, but with this topic it's not just science you are focusing on?
E: No, no it's all areas of it.
R: So when you say the whole staff that is everyone? Not in syndicates?
E: No we decide as a big group, then go off and we plan in our groups –a junior and a senior. So the two seniors go off and plan together and discuss what they are going to teach and how they will do it, and then the junior teachers go off and lower that plan and discuss how we will do it.
R: so both groups will teach the same strands, it just slightly different how you will teach it?
E: yep.
R: Does the principal have much say in what's going on?
E: Umm she is definitely there and involved in our planning and she often questions us, like have you thought about doing this, or what about doing this or why are you doing it that way? So yeah she definitely knows what's involved but when it comes to actual physical planning, no she's not there.
R: So who decided to do water?
E: The whole staff. All of us did.
R: so you all sat down and thought….
E: yeah what are we going to do, what sits with us, what's happening in our environment at the moment and that's what we thought.
R: Okay so the principal more just supports or questions where needed?
E: Uhuh, yep.
R: And how does that work for you? How do you feel about it?
E: Well we all get on really well. Like we are quite a positive easy going staff so it works well. We have the right type of people I guess, we don't have too many similar personalities which is quite good.

R: Are there any particular pedagogical approaches that you use when teaching science?
silence *blank look*
R: Do you have any…
E: Don't laugh at me!
R: no I wouldn't, do you have any teaching tools that you find work, any approaches or strategies?
E: Umm visuals. Most of my kids are visual learners. So I try make sure they have those hands on experiences. Umm for them to actually learn and understand. And not just once, but more than just seeing something happen once. They need to really grasp it and the more they see it the more they understand. I use a lot of YouTube and a lot of online bus

tools. Like for example with water we have done a lot. I've done a lot of research behind [the scenes] – like the water websites we've put in our blogs so they can go home and look through and we've explored it in class, but part of their home work is to spend half hour on the blog, and look over what we've learnt as a revise and refresh thing. Umm otherwise that's probably about it.
R: Are there any particular set approaches that you use? For example have you heard of the 5 E's approach to science?
E: yep I've heard of that
R: so are there any of those types of predetermined approaches that you use?
E: No. not at all
R: have you ever used the 5 E's or anything similar.
E: No I haven't actually.
R: So you don't use any of those tried and tested strategies that are already planned?
E: No.
R: So you do all your planning from scratch
E: Yes all from scratch.
R: But you use a lot of technology?
E: Yes we use, environment Waikato for example, has put out a lot of planning stuff for the likes of water, so we've used that as much as we can.
R: Do you find that their planning relates to the curriculum?
E: Yes yes, they have designed it around the curriculum

R: Okay. So the nature of science, obviously it's in the curriculum, so what does NoS mean to you?
E: That's a tough question…. Ummm.
R: Well you are obviously expected to teach Nos, it's in the curriculum,
E: Yeah...
R: I understand that it's difficult to sit down with a child and tell them this is the nature of science you need to learn this this and this. But we need to include it in some way. So what does it mean to you, and how do you include it in your planning?
E: I guess you incorporate it in everything… because it's so huge…. That it's just one of those... I don't even know. Oh god that's such a tough question….
R: Take your time to think, its fine.
E: what does the nature of science mean to me…..I guess it's all your different elements… I'm not sure how to express what I'm trying to say… umm it's like your real understanding and your grasp of science concepts and…. I guess……. for us in our planning, it's just like a tick box. You know, this is what we're going to do this is why we're going to do it and this is what we are going to focus on. I've never really stopped and thought about its importance. You know when you're doing your planning things are really general because you've got so much to do… I've never really stopped to think about it. You just take things for granted [that it's in there]
R: At university during your degree, did you go over NoS – what it is and why it's in there?
E: Nope. Well, we probably did, but I don't remember. I don't feel like we did. I think that's something that I would remember, I'm sure I would remember if it was important. But a lot of the curriculum isn't explained to you at uni. You know, it's just something that's taken for granted. This is what's written here, now understand it. And that's it.

R: So when you are doing your planning you don't particularly give thought to what areas of NoS you'll be covering?
E: no not really. God, you're making me think! Far out.

R: Okay, leading on from NoS have you ever heard of scientific literacy?
E: Ah no. not specifically.
R: if I asked you to explain what scientific literacy was, and what it means to you?
E: I'm guessing it would be like words associated to science, like terminology and different words that you'd use within science. For example, like words that get thrown around at this age so that they hear them so that when it comes to time when they have to break the terms down and full understand, it's not something that's totally foreign.
R: Right so its familiarising students with science terminology?
E: yep. I guess not just words but phrases and sentences as well.
R: So to clarify, scientific literacy is more the language of science?
E: Yep. Like mathematic language - scientific language.
R: So do you specifically teach or plan for scientific literacy?
E: Yes. Like I make sure there are some words that are brought through. Like for example contamination with water. Especially with juniors, it can be quite technical, so you have to teach them what words mean or they don't understand and then they're out the door. That's one thing I try and keep in the back of my mind.

R: Alright, on to the last question. The NZC – do you find the layout for science helpful for planning?
E: No. not at all. It's so crap.
R: Why, why do you think that?
E: Because it's like level 1 and 2 are basically the same. So many similarities. It's like they want them to be broken down into more explicit things. You feel like you are teaching the same thing, there is no difference. And they use words like "will explore". What does will explore mean?
R: Do you find it easy to understand what the NZC is requiring of you in your planning/teaching?
E: No. no, no. There is so much variety I guess, you want it to be narrowed down a bit. Umm and I guess put into more sections. Does that make sense? I don't know how to explain… because there is so much to cover, science is such a general term that it would be ten times easier if it was more succinct I guess.
R: So you'd find it easier if it specifically said, in year one students will….. and just gave an AO?
E: Yes. It's too vague, too open to interpretation. It needs to be specific in what the students will learn. Would be way easier if it just told me what to do. Like with maths, it's all broken down into the different areas and its way easier to understand. [science] needs a little more structure.

APPENDIX 5
Joyce's Transcript

R: When did you complete your teaching degree?
J: let's see, I've been teaching 30 years
R: 30 years. That's a little bit of experience there isn't it
J: yeah, yeah.
R: how many schools roughly over that period?
J: Well when my children were little I was teaching in London, for about 2 years. Just doing some relieving so perhaps just count that as a couple. So about 8 I suppose.
R: Have you taught pretty much all age groups?
J: yeah
R: so right across the board?
J: yeah, doing new entrant now.
R: but in your last job you were teaching…
J: year 5 and 6
R: bit of a change!
J: yes indeed. I did reading recovery with little ones so it was quite easy to adapt back to this age group here.

R: Alright, so I know it's been a while since you've done your teaching degree but do you know if there was any science element to the degree?
J: Umm I think there was probably, in the earlier years, where you really focused on the curriculum so you had to do a certain amount of science or social studies… it's probably… you really made sure that you did across the curriculum areas.
R: so was there sort of a paper per curriculum area?
J: I think you could choose, I majored in two things, I did PE and Social Studies. So you could choose 2 you focused on for 2 years and then in your last year you majored in one but then you had to do about 5 or 6 weeks of each area.
R: so you had about 5 or 6 weeks where you did have to do science?
J: yeah.
R: so that was for only one of the years
J: yeah I think so.
R: so it was compulsory?
J: yeah… you had to have covered everything.

R: okay so jumping into the next question, what is your understanding of the purpose of science education? Why do you teach it?
J: I look at teaching science because, probably for a couple of reasons. One reason is because you know that you have children in your class that have gifts or strengths in different areas. And as a teacher it is your job to expose them to all of these areas to allow them the opportunity of thinking 'wow I love that', or 'that's a real interest' and you know, through doing that it's kind of like a cycle really. Then they get interested in learning and away they go. So that's one reason. And then you've got to build knowledge as well. So you are building their knowledge of things that happen in the world and what we've

learnt and what we can learn. Hmm. So you are providing opportunities for them to inquire in different ways and then building their knowledge.
R: so would you say that a lot of your science teaching was inquiry based?
J: It’s probably becoming more now. Like you start with a question. umm yeah. Yes.
I don’t know if it would be like that for all the different strands. Because there are strands that you have to have knowledge don’t you, and you build that up.

R: what is it you want the kids to get out of your science lessons? So you’ve said you do it to expose the kids to science and to build their knowledge of the world, to get them to ask questions and build inquiry, but if you were to teach them the science aspect of water, what is it you want them to get out of the science lesson?
J: umm. The understanding. Our question was “what is healthy water?” so we began with cut out pictures of very dirty water and clean water and in-between and I had 3 hoops and we had to categorise them. So that was the beginning of being able to observe. To make observations.
R: so when you say ‘understanding’, what was it that you were trying to get them to understand with that illustration?
J: What healthy water is/looks like.
R: so would you say concepts? Scientific concepts?
J: Umm I suppose… is healthy water a concept? Well we needed to know what healthy water looked like before we could go to the next stage of knowing where to get it or how to change dirty water into clean water. So you had to build a basis of understanding first. Like filtering the dirty water through newspaper, was like the next step.
R: okay, the understanding being the building of knowledge?
J: I don’t know if it was a concept….
R: So why did you use hoops and pictures with this illustration?
J: because it’s visual. They are able to hold onto it, look at it and make an assessment, make a judgement.
R: okay, so it’s visual, you said look at it and touch it, so its hands on.
J: yes and then they knew what the hoops were for
R: would you say it would probably engage them more with the hoops rather than just telling them/talking to them about it?
J: definitely. And like id chosen 3 hoops and I didn’t think of the colours. But I had a blue hoop as the dirty one. And they were really quick to tell me that it should be the clean one.

R: okay, so when you are planning for science, who decides what topics, concepts, skills will be taught and when they will be taught.
J: Well I think in this school, because we are an enviroschool that underpins everything that we do. I don’t know who made the decision that water was the question that we would be looking at but, umm I guess management decided on that. From that we went to groups to plan together.
R: alright so, management decided on topic, which was the enviro topic?
J: yes
R: and then from there you went into groups?
J: syndicates.

R: cool, so in those syndicates did you plan all your curriculum areas together since they all came under the enviro topic?
J: um no. As new entrant I find you can't do that. I see my job as teaching them literacy and math so how to read and write and then the topic…you know you can't get enough stories around water. If there was, you'd use them. But no, it was purely a topic based thing that I did in the afternoons. Although in saying that you could incorporate it into your writing.
R: okay so syndicates plan units, however you adapt your planning to suit your kids
J: yeah

R: so are there any particular pedagogical approaches you use when teaching science?
J: umm
R: Well not even just for new entrant, but over the years with different age groups have you used any particular approaches?
J: ummm a few years ago I did wind power toys and we went over to the wind farm at Raglan and from there they learnt the concept of the wind causing the arms to go around into cogs and from there, one of my achievement objectives were "investigate examples of simple technology devices and link these with some scientific ideas". So we did that in about 8 weeks. And it was a science fair thing, so they had to define the problem, gather the information, analysis it, they kept a log book, had a design and plan, evaluate. The investigation method.
R: so that planning you did, did you come up with that yourself or was that based on a sheet that you'd been given?
J: umm I honestly can't remember but I would have used TKI a lot. I think I went to a science teacher from a collage and went through it properly so that I knew that I was heading in the right direction. I used the key competencies. So we had a research question: does the wind have energy? And then: how can we capture that energy?

R: are there any particular science planners that you use?
J: at this school we try something new, called IUGO. It made sure we encompassed all levels of learning. But at my last school we had a basic plan that was given to us. We use to ensure that we had a range of science majors throughout the year. About twice a year for science.

R: What does the nature of science mean to you and how do you include it in your teaching and planning? So in the curriculum we have the nature of science at the top. So basically I want to know why you think it's there, what does it mean, and do you teach it explicitly?
J: I think the word investigation comes to mind. Because it's a perfect tool to use in science to promote questioning and you can see in different children how it sparks that sort of "oh yes I know about that". I won't say particularly in boys, because my daughter ended up teaching chemistry and physics. But when I look at these little kids it tends to be the boys that love to talk about space or, you know. So yeah I think investigation, questioning, you know, you must do that. You must as a teacher.
R: okay, so that is your understanding of NoS? The investigation and the questioning?

J: Mmm yes.
R: so how do you include that in your planning?
J: well when you plan you know what you want to end up with, so you have to go backwards in a way and think how am I going to get to that end? There might be perhaps a way you haven't used. Yeah you've got to be innovative and think. I think that's what a good teacher does, uses different skills or techniques to get to that end.
R: okay, so if you look at NoS it's got 4 different strands with achievement objectives for each underneath. Do you specifically include those AOs into your planning? Or the strand headings?
J: I think you have your main concept that you want to zero in on, and you have to do that.
R: You mean a scientific concept?
J: yes, the point of teaching that lesson
R: so would you incorporate NoS into that concept learning?
J: umm yeah you'd incorporate it.
R: in your planning, you have your learning intentions etc, do you have NoS learning intentions that you include in there as well?
J: umm probably. That would be good. Whether you reach them or not, you know. But if you haven't made yourself aware of them I think you lose it. You've got to be on track.

R: have you ever heard of scientific literacy?
J: umm where?
R: okay, well, if I was to say 'scientific literacy, what does it mean to you?', what would you think that would include?
J: uh terminology.
R: cool. Okay, so it would be concerned with scientific terminology?
J: yes, building the children's literacy. You know, you want to teach them the correct words and terms.
R: okay, and how would you teach/plan for scientific literacy.
J: well you'd use that in your planning. You'd have specific terms or words you wanted to include and you'd have those in the planning. I think as you go up the school age you would know how much you wanted to guide, how much you wanted to direct. How much you wanted them to discover.

R: so for you, would you see science as an individual endeavour or as a group, community.
J: it can be both I think
R: yep. What do you mean by that?
J: Through the children's own reading, listening, going online, through their own discoveries themselves, they would build a knowledge themselves. And then in a group working environment they would do the same. They would discover things together, they would feed off each other.

R: Alright, so coming to our last question, how do you find the NZC layout for science planning? Is it helpful?
J: yeah I find it helpful. I think it's good.

R: cool, so you find it easy to follow and understand, and you know what you are required to teach in the science education section?
J: yes, I think it’s specific.

APPENDIX 6

Information and consent letter to principal

Hayley Ryan
3 Piwakawaka Court,
Rototuna, Hamilton

Telephone: 027 267 3373
E-mail: luvhayley@hotmail.com

November 2015

Dear_________ (principal)

I am writing to invite your school to be a part of case study I am conducting around current primary teachers' perspectives about the purpose of science education. The aim of this study is to assess teachers' understanding of the purpose of science.

This case study will form the basis of a thesis for a Master of Education Degree which I am currently enrolled in at the University of Waikato.

If you are agreeable, I would like to invite two teachers from your school to consent to be part of my research. By participating in the research teachers have the opportunity to highlight and/or heighten their awareness of best practice in science teaching, especially around scientific literacy curriculum goals, in ways that enhance their students' learning experiences and achievement in science. This research can help bridge the gap between theory to practice by providing greater understanding of what is actually happening in our classrooms and why.

This study will require the teachers to participate in a one-on-one interview with myself and provide me access to their science planning where appropriate. I will also seek your permission and that of the teachers for photocopies of their science planning, worksheets or other resources that are relevant, and to audio record the interview with the individual teachers.

Informed consent will be sought from the teachers before any of these activities take place. I will check on a regular basis that the teachers are happy with the progression of the study and remind them that they reserve the right to withdraw from the study at any point during the research and the right to withdraw their data up until they have approved the transcripts. At mid-point I will also check that you are happy with the progress, and remind you that the school also reserves the right to withdraw from the research up until the data has been gathered and approved by participants – if you have any concerns at any point I will always be available to meet with you.

The raw data collected from your school will only be used to complete my thesis, however my thesis may be used in other scholarly publications. An electronic copy of the thesis will become widely available, as Master thesis are required to be lodged in the

University’s digital repository: Research Commons. Pseudonyms will be used in any reporting of the work to protect the anonymity of your school and all participants. As a consequence, the contribution of individual teachers will not be able to be acknowledged in a public forum. Please note that while every effort will be made to ensure confidentiality, it cannot be guaranteed.

I am excited about this project, and would greatly appreciate your permission for your school to be involved. If you need any more details please contact me at the above address. In the event of any issues arising from the research you can also contact my supervisor, Dr Anne Hume (e-mail – annehume@waikato.ac.nz; Tel. – 07 8562889 Ext 7880.

If you are willing for your school to be involved, please sign the attached consent form and I will come and collect it from you.

Yours sincerely
Hayley Ryan

Principal Research Consent Form

I have read the attached letter of information.
I understand that:

1. My school's participation in the project is voluntary. ☐

2. The researcher will check at the mid-point that I am happy with the progress of the project. ☐

3. Informed consent will be gained from any teacher taking part in the research before collecting any data from them for this project. ☐

4. Data may be collected from my school in the ways specified in the accompanying letter. These data will be kept confidential and securely stored. Any reporting of the data will be done using pseudonyms. ☐

5. Data obtained during the research project will be used for the production of a Master Thesis. As such, an electronic copy of the thesis will become widely available, as Masters Thesis are required to be lodged in the University's digital repository: Research Commons. ☐

6. I can direct any questions to Hayley Ryan, University of Waikato (e-mail: luvhayley@hotmail.com, Tel. 027 267 3373). ☐

7. For any unresolved issues I can contact Hayley's supervisor, Dr Anne Hume (e-mail annehume@waikato.ac.nz, Tel. 07 8562889 Ext 7880 ☐

I give consent for my school to be involved in the project under the conditions set out above.

Name: ___________________________________

Signed:___________________________________

Date:____________________________________

APPENDIX 7
Information and consent letter to participants

Hayley Ryan
3 Piwakawaka Court
Rototuna, Hamilton.
Telephone: 027 267 3373
E-mail: luvhayley@hotmail.com

November 2015

Dear____________ (participant)

I am writing to invite you to participate in the research involved in my Masters project. The aim of this study is to explore teachers' understanding of the purpose of science education.

I have already written to the principal, who has given permission for me to invite you to participate in this project. Your involvement will require an interview (that should take no longer than 30 minutes) for the purpose of discussing your views, opinions and beliefs as to why and how you teach science. With your permission this interview will be audio recorded to ensure accuracy and avoid misinterpretation (by me) of comments you make. A transcript will be provided to you to check and amend any inaccuracies.

Secondly I am asking your permission to look over your science planning, which may involve viewing copies of your planning materials, worksheets or other resources. Any information obtained from you will be stored in a locked cabinet or on a password protected computer and no one else will have permission or access to the raw data or copies of materials you provide.

Any data that are collected will be coded to protect your anonymity, as well as that of your students and your school. This anonymity means that your individual contributions will not be able to be acknowledged within a public forum. I will check on a regular basis and at the mid-point that you are happy with the progression of the study. Please note that you reserve the right to withdraw from this study at any point while the research is being conducted, before the analysis process has begun.

The findings will be used to produce my Master thesis for the University of Waikato. An electronic copy of the thesis will become widely available, as Masters Theses are required to be lodged in the University's digital repository: Research Commons.

I am excited about this project and hope that you will be keen to be involved. If you need more details, please contact me at the above address. In the event of any issues arising from the research you can also contact my supervisor, Anne Hume (e-mail annehume@waikato.ac.nz; Tel. 07 8562889 Ext 7880

If you are willing to participate in this project, please sign the attached consent form and return via the self-addressed envelope included.

Yours Sincerely,
Hayley Ryan

Research Consent Form for participants

I have read the attached letter of information.
I understand that:

1. My participation in the project is voluntary. ☐

2. The researcher will check at the mid-point that I am happy with the progress of the project. ☐

3. I have the right to withdraw from the study at any time while the research is being conducted – up until the data has been analysed. ☐

4. Data may be collected from me in the ways specified in the accompanying letter. These data will be kept confidential and securely stored. ☐

5. Any data will be reported using pseudonyms in order to protect the anonymity of me, the students in my class, and my school. ☐

6. Data obtained during the research project will be used for the production of a Master thesis. As such, an electronic copy of the thesis will become widely available, as Master theses are required to be lodged in the University's digital repository: Research Commons. ☐

7. I can direct any questions to Hayley Ryan, University of Waikato (email: luvhayley@hotmail.com, Tel. 027 267 3373). ☐

8. For any unresolved issues I can contact the Masters supervisor, Dr Anne Hume (email: annehume@waikato.ac.nz, Tel. 07 8562889 Ext 7880). ☐

I am willing to be involved in this project under the conditions set out above.

Name:____

Signed:_______________________________________

Date:____