Ngāti Whakaue Iho Ake – An Iwi Science Education Exploration

By

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HE HAKA

I tūhia mai nei tō reta pōhiri kia mātou

Kia tae mai ki Rotorua

Aha ha ha

I haramai haramai taku taonga

Aha ha ha

I au ai kia whakatairangatia te kaue o taku tupuna

Tama te Kapua e tū nei

Titiro ki ana uri e tau nei

Aha ko mātou

Ko mātoa aha

Ko Uenuku aha ha

Te korapanga o te wā o Pukaki

I waiho ki a Te Taupua

You have invited us to come to Rotorua

Well then we are here and have brought our treasures

Well then we have come to proclaim the (jawbone) symbol of our

Illustrious ancestor Tama te Kapua

Behold (we are) his progeny who gather today in numbers

Yes we are his descendants we are his children

And the children of Uenuku well then

We declare ourselves the survivors

From the time of Pukaki

Coming down to Te Taupua today

HE MIHI

Anei te mihi maioha ki ōku tūpuna kua wheturangitia, ko rātou kua mene atu ki te pō, kua okioki i tēnei wā, moe mai moe mai rā koutou

Ko Herbert Wharerau Maaka McRae tēnā

Ko Benjamin Rangihonohono Morrison tēnā

Ko Wimareux Te Iwa Gillies tēnā

He reo ohaaki tēnei ki a koutou

Ko Winipere Caroline Milroy ka ora tonu

He reo aroha tēnei ki a koe

Ko Fredrick Matthew McRae tōku pāpā

Ko Kahira Martha Morrison tōku māmā

He reo hūmarie tēnei ki a kōrua

Ko Ngāti Whakaue rātou ko Ngāti Kahungunu me Ngāi Tuhoe ngā iwi

Ko au te uri e whai mai nei

Ko Hiria Stacey McRae tōku ingoa

Anei te mihi maioha ki a tātou hoki ko te hunga ora

Nō reira

Tēnā koutou

Tēnā koutou

Tēnā koutou katoa

ABSTRACT

This thesis aims to provide a pathway to improve Māori student engagement with science education. Internationally, some indigenous communities have worked with schools in the delivery of science programmes, resulting in positive indigenous student engagement. These outcomes show that together indigenous students, schools and indigenous communities can contribute to the development of their particular place when science programmes allow the exploration of self, relating to others, the local environment and the wider world. This thesis investigates the perceptions of Māori students, teachers and kaumātua of science education in the Māori tribal community of Ngāti Whakaue to identify how Ngāti Whakaue is recognised in school science programmes. Individual and focus group interviews were conducted with local Māori elders, Māori secondary science students, and secondary science teachers from six English and Māori medium secondary schools in Rotorua. Data analyses revealed that participant perceptions and experiences of place, science and the Māori culture were disconnected from Ngāti Whakaue, despite its rich potential as a setting for science education. Participants held diverse perceptions and views within and between groups, including student and teacher understandings of Māori culture, attitudes regarding the place of Māori culture and knowledge in science education, and preferences regarding teaching and learning styles. Findings are examined as to how schools and Ngāti Whakaue could work together to better support positive Māori student engagement with science education and suggestions are made about how these relationships could be improved.

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CONTENTS

CHAPTER ONE – INTRODUCTION

1.0 Background

This thesis is about providing a pathway to improving Māori student engagement with science education. Indigenous community-based science programmes are examined globally to identify common principles that have been supportive in addressing common issues in science education for indigenous students, including Māori. More specifically, the thesis examines one Māori community's perceptions and engagement with science education as a means of examining a Māori community-based approach for this learning area. Drawing on these perceptions it suggests a transformative pathway for Māori communities to consider if one of their educative goals is to improve the engagement of their Māori students in science education.

Recent New Zealand education initiatives aimed at supporting Māori student achievement in education make statements about supporting Māori students to achieve success as Māori (Ministry of Education, 2009, 2011). To understand the concept of 'being Māori' it has to be understood that there is no one way to be Māori and most Māori identify themselves through their whānau (family), hapū (sub-tribe) or iwi (tribal) affiliations (Penetito, 2010). Therefore, education initiatives aimed at supporting Māori student achievement in any area or at any level of education should be developed with Māori communities, based on their perceptions of being Māori and measures of education success.

This chapter begins by exploring my personal connection to the context of this thesis. Next, a description of the context of this study will be provided, followed by the research question and aims. How I locate myself within the research context and the scope and limitations of the research will also be outlined. The chapter concludes with a brief outline of the thesis.

1.1 Rationale

Māori student achievement in science education has been an issue for the New Zealand education system since Māori student progress was first researched in the early 1980s (Stead, 1982). The under-achievement of Māori in science education is still evident (Ministry of Education, 2004), despite initiatives in a range of areas (McKinley, Richards, & Stewart, 2004). McKinley (2005) suggests that improved Māori performance achievement in science education could be achieved with schools working alongside Māori communities, where Māori culture, language, knowledge and pedagogy are included in the science education of Māori students. Schools working alongside indigenous communities have been observed as a key factor in improving indigenous student achievement in science education (Aikenhead, 2001; Barnhardt & Kawagley, 2005; Cobern & Loving, 2001; McKinley, 2005; Snively & Corsiglia, 2001; Stanley & Brickhouse, 2001).

My personal interest in science education began as a child with a love of science, supported by lots of books in our home, family outings, and experiences at school. I am not a formally trained scientist, but loved science at school and did very well academically. I had hoped to pursue a science career; however, I chose instead to become a Māori medium primary school teacher. Science and technology were my favourite curriculum areas to teach at primary school and I have also taught and advised pre-service and in-service teachers in these areas. These professional teaching roles have led me to learn more about areas such as environmental education and education for sustainability. As a teacher educator, I have become more aware of the low participation and achievement of Māori students in science education. My post graduate studies introduced me to other related areas such as the contentious interface between Māori culture and science. All of these experiences have contributed to my interest in making a difference for Māori communities and science education.

One of my Māori communities is Ngāti Whakaue, an iwi predominantly located in the city of Rotorua in the central North Island of New Zealand. Science education has been a specific focus area for Ngāti Whakaue, since a report contracted by The Ngāti Whakaue Education Endowment Trust Board identified science education as a target area for further support (Cooper, Roddick, Hodgen & Wylie, 2003). The report provided baseline data of education achievement and delivery in Rotorua and the Ngāti Whakaue small town of Maketu, as a means of identifying areas of concern that may need future development. Four priority areas were identified and recommended the board as being the most important for improvement in educational achievement. These included early childhood education, secondary education, attracting

Māori teaching staff (particularly Ngāti Whakaue), and support for governance (Cooper, et al., 2003).

One of the main activities suggested by the research was to focus on secondary school mathematics and science education achievement, because of the low achievement results of Ngāti Whakaue students in these areas. Possible strategies included shared professional development between all Rotorua secondary schools in the areas of mathematics and science, and shifting tertiary funding to secondary schools (Cooper, et al., 2003). There is no evidence that the recommendations in regards to science education have been actioned by Ngāti Whakaue and Rotorua secondary schools. The overall aim of my research is to identify whether indigenous community-based science programmes could be an approach to support the implementation of the strategies identified as ways of improving science education achievement for Ngāti Whakaue.

1.2 Research Question and Aims

The overall research question for this study was:

How do schools include Ngāti Whakaue in science education?

The focus of this research is indigenous science education, specifically Māori science education within the setting of one Māori tribe in New Zealand, Ngāti Whakaue. The purpose is to examine how Māori senior science students, and their science teachers, and local elders in the Ngāti Whakaue setting engage with and perceive science education. This thesis aims to identify potential issues, benefits and challenges that would need to be considered if the Ngāti Whakaue community chose to pursue an indigenous community-based approach to science education.

1.3 Context of the Study

The Māori New Zealand iwi of Ngāti Whakaue is descended eight generations from Tametakapua, the ancestral chief of the Te Arawa people, through Whakaue Kaipapa (Stafford, 1967; Tapsell, 2000).

Tametekapua

I

Kahumatamomoe

I

Tawakemoetahanga

I

Uenukumairarotonga

I

Rangitihi

I

Tūhourangi

I

Uenukukōpako

I

Whakaue

Ko Ngongotaha te maunga

Ko Rotorua a Kahumatamomoe te moana

Ko Tamatekapua te tangata

Ko Te Papaiouru te marae

Ko Ohinemutu te papakāinga

Ko Ngāti Whakaue te iwi

Ko au te uri i raro iho nei

Ngongotaha is the mountain

Rotorua a Kahumatamomoe is the water

Tamatekapua is the ancestor

Te Papaiouru is the meeting place

Ohinemutu is the settlement

Ngāti Whakaue are the people

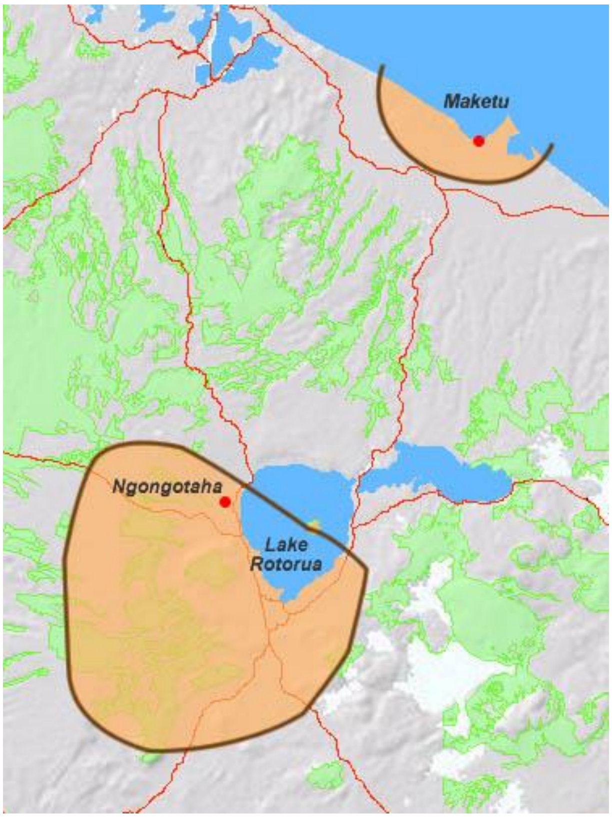
I am their descendant

My parents were born and raised in Rotorua and both affiliate to Ngāti Whakaue through their fathers, my grandfathers. Both sets of my grandparents lived most of their lives in Rotorua and I have extensive blood relatives there. I have lived away from Rotorua for almost 11 years; however, I regularly return for holidays, family occasions, and work.

Whakaue's descendants inhabit both the coastal village of Maketu (See Map 1.3a) in the Eastern Bay of Plenty of New Zealand, which is also the historical landing place of the Te Arawa waka (ancestral canoe) from Hawaiki (ancestral homeland), and the city of Rotorua (See Maps 1.3a & 1.3b).

Map 1.3a: Location of Rotorua, New Zealand

Map 1.3b: Location of Maketu and Rotorua city



Whakaue had six children and it was during the time of his son Tutanekai, famed for the story of his love for Hinemoa, that his descendants became known as Ngāti Whakaue (Stafford, 1967). The current six main sub-tribes of Ngāti Whakaue are named after Tutanekai's grandchildren and great grandchildren, Hurunga te Rangi, Pukaki, Rangiiwaho, Taeotu, Te Roro o te Rangi, and Tunohopu (Tapsell, 2000).

The most recent demographic information shows that 7,311 people or one percent of the total Māori population have named Ngāti Whakaue as their main iwi, or as one of their iwi (Statistics New Zealand, 2006). Twenty-seven percent identified Ngāti Whakaue as their sole iwi and 73 percent affiliated with other iwi. The majority (95%) of New Zealand based Ngāti Whakaue lived in the

North Island of New Zealand while the remainder lived in the South Island at the time of the 2006 New Zealand Census. There was no clear information of what percentage of Ngāti Whakaue were overseas at the time of the 2006 census, however, three percent stated they were living overseas during the 2001 census (Statistics New Zealand, 2006). The majority (86%) also live in urban areas. The population across age groups include 34 percent under the age of 15, 22 percent aged 15–29, 39 percent aged 30–64, and 5 percent over 65 years. Fifty-four percent of Ngāti Whakaue were female and 46 percent male (Statistics New Zealand, 2006).

In regards to education, 71 percent of Ngāti Whakaue aged 15 years and over held a formal qualification in comparision to the total Māori population where 63 percent held a formal qualification (Statistics New Zealand, 2006). Thirty-five percent had a school qualification as their highest qualification, 12 percent had a bachelor's degree or higher and 31 percent had no formal qualification. Twenty-eight percent of Ngāti Whakaue women and 31 percent of men had no formal qualifications. The over-65 age group had the highest proportion of people with no formal qualifications (Statistics New Zealand, 2006).

The Ngāti Whakaue Education Endowment Trust Board is the main organisation that aims to support education issues for Ngāti Whakaue students and also education institutions based in their area (Cooper et al., 2003). Historically, the Rotorua High School Board managed funds generated from rentals of Ngāti Whakaue land, gifted to local government for education purposes. Currently the board comprises of six members appointed by the

Pukeroa Oruawhata Trust and five members from five Rotorua secondary schools (Ngāti Whakaue Education Endowment Trust Board, 2012).

Since the establishment of the board a main focus has been to support initiatives that enhance 'Ngāti Whakauetanga' including Ngāti Whakaue history, knowledge, language and protocol. Education initiatives have included tertiary education grants, language and protocol revitalisation programmes and literacy and numeracy programmes in primary and intermediate schools (Cooper, et al., 2003). The first formal education strategy was created in 2001 directed by the proverb 'Ngāti Whakaue Iho Ake' or the collective values and strength of Ngāti Whakaue whakapapa (geneology), tikanga (protocol) and kawa (procedures). Goals included the development and implementation of programmes in the areas of te reo Māori (Māori language) and tikanga development, support for families, monitoring of the delivery of education services to Ngāti Whakaue, research infrastructure, and alliances with other education agencies (Cooper, et al., 2003).

1.4 Locating Myself in the Research

My involvement in Ngāti Whakaue education has followed the process of receiving tribal funding for my tertiary education, completing my tertiary education and through my career as an educator. I have recently had the opportunity to integrate my Ngāti Whakaue values and interests into some of my work as a member of a Ngāti Whakaue-affiliated research group working on locally focused projects.

My first experience of Ngāti Whakaue's education plans was when my two older sisters received monetary grants for their tertiary studies. Ngāti Whakaue is a major landowner and shareholder of assets in Rotorua. Education is one area that Ngāti Whakaue invests in (Ngāti Whakaue Education Endowment Trust Board, 2012). I too received monetary scholarships from Ngāti Whakaue during my tertiary studies. I also know that Ngāti Whakaue give funding to a lot of schools in Rotorua. In 2012 twenty-five schools in Rotorua received a total of $470,000 (Ngāti Whakaue Education Endowment Trust Board, 2012). Most recently the research group mentioned earlier that I'm a part of has also received Ngāti Whakaue funding for a Rotorua-based education research project (McRae, Macfarlane, Webber, Cookson-Cox, 2010).

Ngāti Whakaue's Education Endowment Trust Board, has existed for over 100 years. There are a number of sub-committees making up this board, which have managed a range of initiatives. My father has been a member of the Ngāti Whakaue Education Endowment Trust Board for a long time, along with other close family members. In the last five years some of my siblings and I have been involved in some of the tribal education initiatives.

My first formal contribution to my tribe was as a night-class tutor teaching adult tribal members the Māori language. This was part of a Māori language initiative funded by Ngāti Whakaue. Due to a range of reasons, most related to language loss, tribal-funded Māori language revitalisation programmes are common for many tribes in New Zealand. My second formal contribution was as an author of a set of books to promote Māori language use in the home with young children. I wrote the books with one of my younger sisters and some of my immediate family were involved in the photography for the books. The books were based on places and activities unique to Ngāti Whakaue.

It is common for many Māori tribes in New Zealand to organise these types of Māori language initiatives through promoting literacy in the home (Ministry of Education, 2013b). A common aim of such initiatives is to base the text in the context of the specific Māori tribe to promote the dialect, protocol, and vocabulary of the tribe. It was during my involvement in this project that I first experienced tensions between what schools in the city environment were offering in science education and what seemed to be Ngāti Whakaue educational aspirations in this field. The main example of tension was clarifying, understanding, and coming to a consensus with the Ngāti Whakaue education trustees about what the set of books would contain and how they would be used in the home. I also observed similar tensions with my older sister and her experience of the sorts of things she wanted for our children.

My older sister was head teacher for a Ngāti Whakaue-focused early childhood centre. The aim of the centre was to encourage parents to be involved with their children in formal early childhood education in a Ngāti Whakaue context. The main reason for the tension was the need for the Ngāti Whakaue education trustees to reach a consensus with my sister about what would be taught in the early childhood centre and how it would be delivered.

My sister's involvement in the centre and my interest in this unique tribal education approach led me to apply for a research project based around the centre. The research was funded in partnership with the Ministry of Education in New Zealand and was aimed at exploring relationships between the Ngāti Whakaue context of the early childhood centre and positive parent and student participation in early childhood education. I was an unsuccessful applicant; however, it was a rewarding experience to engage with my tribal community on a research level.

I also belong to a research group which has the interest of Ngāti Whakaue as central to its philosophy, principles, and vision. All members of our research team affiliate to Ngāti Whakaue. We have all committed to being involved in this group over and above our everyday jobs and receive no remuneration for our work. Our first research project was based in one secondary school in Rotorua that has strong links to Ngāti Whakaue. We are planning to expand the project to work with all of the secondary schools in Rotorua. Ngāti Whakaue has endorsed our future project and is committed to supporting it with funding. We are all interested in providing practical outcomes for Ngāti Whakaue as a result of our research, such as professional development workshops for schools.

In the primary school setting, I only know of one Ngāti Whakaue-funded programme. It is a literacy programme developed and delivered by a long-standing Ngāti Whakaue teacher in a few Rotorua schools. I am not aware of the progress of this initiative. I have been a part of the planning group for a

Ngāti Whakaue-funded science camp for primary-aged children. The focus was to work with primary-aged children to possibly influence or support their secondary school science choices. The camp was based at one of the traditional tribal meeting places and facilitated in partnership with tribal members and facilitators from a range of local science institutions. Children were involved in daily workshops either at the tribal location or the institution, across one week during the school holidays. It is still in its early stages with only one camp held so far, which had some positive reviews from parents and children who attended.

One of Ngāti Whakaue Education Endowment Trust Board's aims is to improve Ngāti Whakaue student achievement in science education (Cooper, et al., 2003). The science camp was organised to support this aim. In my involvement in the planning of this event, I asked the organisers about their communication with schools regarding science camps. There had been no communication to seek advice or support, or to promote the science camp with schools. Advice and support had only been sought from Ngāti Whakaue members within the science organisations promoted through family networks. This lack of collaboration is in opposition to the research outlined earlier in this chapter which was conducted to identify areas of improvement in education which recommended that Ngāti Whakaue and schools to work together in the area of science education (Cooper, et al., 2003). This evidence of limited engagement between Ngāti Whakaue and schools has provided further impetus for the need to research possible pathways to improve the working relationship between

Ngāti Whakaue and schools in improving Māori student engagement with science education.

1.5 Scope and Limitations of My Research

Ngāti Whakaue is only one part of the unique setting that is Rotorua and there are many other components that contribute positively to Māori student achievement in science education in this area. The study, though, is primarily about making a difference for the Ngāti Whakaue community. It is not exclusive and will hopefully contribute to the wider Rotorua science education community. This is an exploration of some members of the community of Rotorua and their interaction with science education. It is an exploration observed and interpreted by one member of that community. The intent of this research project is to tell their stories and offer possible opportunities for this particular community. It is also intended that other indigenous and science education communities see opportunities.

The secondary school setting was chosen for a range of reasons. Māori students who were taking senior science subjects were chosen, as it was assumed that they had participated and achieved positively in science education at a primary and intermediate level to be able to or want to engage with senior science. The intent of my research is about what engages Māori students to participate, not how well they were achieving. I also wanted to provide a positive lens to this research as studies about Māori student achievement often give a deficit view. This study is not primarily intended to provide recommendations for all Māori secondary school students or secondary school science programmes. However, it offers suggestions for all science education programmes for all Māori students at all levels of education. English and Māori-medium settings were chosen as this is the reality of our secondary school classrooms in Aotearoa New Zealand. The majority of Māori students attend English medium schools (Ministry of Education, 2013a). This research aims to provide a perspective of the unique setting that is Rotorua, not to provide a comparison of the school medium settings.

1.6 Thesis Outline

This thesis is divided into six chapters. Chapter One has provided the research focus, rationale and context and has identified the main research question. This chapter also located the researcher in the study context and outlined the scope and limitations. Chapter Two examines literature associated with the research focus, identifies key issues, and examines current examples of indigenous community-based science programmes as a means of identifying key elements that contribute to successful implementation. Chapter Three describes a theoretical framework based on the principles of a successful indigenous community-based science education programme identified in Chapter Two, and makes connections to one perspective of Kaupapa Māori theory and one of Kaupapa Māori science education. Place-based education theory and its relevance to this study is also introduced in this chapter. Chapter Four outlines the research design chosen to examine the main research question. Chapter Five presents the findings of the qualitative study of Ngāti Whakaue-located participants. Chapter Six critically discusses how the research findings address the research question and contains the conclusions and recommendations of this study.

CHAPTER TWO – LITERATURE REVIEW

2.0 Introduction

The main focus of this literature review is to examine the current state of indigenous community-based science programmes to identify what makes them successful in improving the outcomes of indigenous students in science education. Another important purpose of this review is to explain the two main contexts of this research, which are Ngāti Whakaue and science education. These central foundations represent a common area of tension in science education, which is the inclusion of Māori culture as a response to improving the engagement and outcomes of Māori students (Waiti & Hipkins, 2002).

There are varied definitions of what Māori culture encompasses, for example Durie (1995) includes aspects of identity and wellbeing, May (1998) adds language, and Bishop and Glynn (2000) incorporate language and knowledge. This thesis acknowledges these views and defines Māori culture as perceptions of identity, knowledge and language. Identity is included as an important aspect of Māori culture, as identity encompasses views and beliefs about how groups of Māori relate to the world around them. Knowledge is also imperative, as Māori bodies of knowledge describe what Māori observe, interpret and know about the world. Finally, Māori language is the vehicle to communicate and share their views, beliefs, observations and perpectives. These elements are explored in Section 2.1 of this chapter; each first from a pan-Māori perspective, then from a Ngāti Whakaue perspective. Individually these topics are immense; therefore, this literature review presents only a brief summary relevant to the purposes of this study.

In Section 2.2 of this chapter, science education will be discussed and first explores the nature of and relationship between science and indigenous knowledge. A view of the aims and purposes of science education will then be provided. Science education will also be examined in relation to indigenous students, Māori students and culturally responsive schooling. This section will conclude with a brief justification of the need for indigenous community-based science education programmes.

Section 2.3 summarises the international literature concerning facilitation of indigenous community-based science programmes. It presents a set of principles identified as having contributed to the successful facilitation of programmes that aimed to address low achievement of indigenous students in science education. Evaluation of what makes these types of programmes successful is an area of research that is yet to be thoroughly explored. These principles are proposed as an approach that could be used in Māori communities to develop, examine and enhance community-based science programmes that could benefit all involved. In this thesis they will be applied as a framework guiding the research design and data analysis within the Ngāti Whakaue context. The Ngāti Whakaue context is described in the section below.

2.1 Who are Ngāti Whakaue?

This section aims to explain how Ngāti Whakaue will be defined throughout this thesis. Ngāti Whakaue is the key focus for this study. Ngāti Whakaue will be described through elements that are agreed to define Māori culture (Bishop & Glynn, 2000; Durie, 1995; May, 1998), first through Māori identity, next knowledge and, finally, language.

2.1.1 Ngāti Whakaue as Māori

A traditional view of Māori identity (Durie, 1998; Walker, 1990) and more recently stated as a primordial foundation (Penetito, 2010; Webber, 2008) of Māori culture is whakapapa or genealogical connections with all living and non-living things. Ngāti Whakaue whakapapa descends from eight generations, beginning with Tamatekapua, the chief of Te Arawa canoe that travelled from the ancestral land of Hawaiki (Stafford, 1967; Tapsell, 2000).

Tametekapua

I

Kahumatamomoe

I

Tawakemoetahanga

I

Uenukumairarotonga

I

Rangitihi

I

Tūhourangi

I

Uenukukōpako

I

Whakaue

Whakapapa includes both links to tūpuna or ancestors (Durie, 1998; Walker, 1990) and geographical boundaries, such as mountains, bodies of water and other land features (Carter, 2005; Penetito, 2010). Traditionally, these boundaries were used to determine tribal territories and were identifiable, communicated and maintained across generations through various types of oratory, such as waiata (songs), whaikōrero (formal speeches), pēpeha (introductions) and pakiwaitara (stories) (Carter, 2005; Mead, 2003; Mead & Grove, 2001). An example of a Ngāti Whakaue pēpeha could include the following links to geography and ancestry:

Ko Ngongotaha te maunga

Ko Rotorua a Kahumatamomoe te moana

Ko Tamatekapua te tangata

Ko Te Papaiouru te marae

Ko Ohinemutu te papakāinga

Ko Ngāti Whakaue te iwi

Ko au te uri i raro iho nei

Ngongotaha is the mountain

Rotorua a Kahumatamomoe is the water

Tamatekapua is the ancestor

Te Papaiouru is the meeting place

Ohinemutu is the settlement

Ngāti Whakaue are the people

I am their descendant

This particular pēpeha encompasses common aspects of Māori identity discussed earlier, such as ancestral and geographical links (Carter, 2005; Durie, 1998; Penetito, 2010; Walker, 1990) and also makes historical, political, economic and social claims (Mead, 2003; Mead & Grove, 2001). A historical claim is represented by the named places, people and associated past stories. Stating claims to physical boundaries and resources is both political and economic. Finally, the social claim is represented by the individual asserting themselves as a descendant of a collective group. Penetito (2010) states that for many Māori, individual identity is intimately linked to the collective. However, the complexity of this relationship and the nature of making identity-related claims changed with European contact with Aotearoa New Zealand.

The first change in how Māori identified themselves when European settlers arrived was from being known as distinctive tribes to the pan-tribal term of Māori (ordinary or normal) as a means to differentiate themselves from non-Māori (Rata, 2012). The most significant change to Māori society was caused by colonial structures aimed at acquiring and controlling fiscal resources (Walker, 1990). Fundamental aspects of Māori culture were affected, for example, Māori collective land ownership (individualistic legislation), Māori spirituality (Christianity), Māori language and knowledge (assimilative schools) and Māori health (oppressive legislation) (Rata, 2012). Ngāti Whakaue experienced all of these structures, which enhanced the need to state their identity through claiming formal physical boundaries, especially to maintain their fiscal resources (O'Malley & Armstrong, 2008). The original motivation for Ngāti Whakaue to engage with early European settlers was access to new technology, specifically muskets, as they had suffered a great defeat to the Northern tribe of Ngā Puhi due to Ngā Puhi having a supply of muskets (O'Malley & Armstrong, 2008). This event remains an important part of Ngāti Whakaue history for many different reasons, which included the brave act of female ancestor Te Ao Kapurangi (Stafford, 1967). Ngā Puhi leader Hongi Hika allowed her to save her Ngāti Whakaue people who could fit between her legs; so, with her courage and intellect, she sat atop a meeting house to save as many as could fit within (Stafford, 1967). Te Ao Kapurangi's heroic actions are still revered today (O'Malley & Armstrong, 2008) and is an example of how historic events are a significant component of specific Māori tribal identity.

Rata (2012) argues that Māori identity had traditionally been diverse; however, due to colonial processes and other dynamics introduced with the arrival of Europeans, such as intermarriage, new perspectives about Māori cultural diversity have emerged. Other commentators on contemporary views of Māori identity have attempted to categorise Māori socially (McIntosh, 2005; Webber, 2008) and politically (Durie, 1998; Walker, 1990) for a range of different agenda

(Penetito, 2010). Common assertions about contemporary Māori identity state that Māori diversity needs to be acknowledged and affirmed (Rata, 2012); that individuals can self-identify as a Māori and to a collective group of Māori; and can also acknowledge European whakapapa (Meredith, 1999). Penetito (2010) also states that historically and currently Māori expression of identity is situational and fluid, so therefore deserves diverse considerations and opportunities (Webber, 2008). These views and assertions about (identity) and for (rights) Māori imply the importance of recognising traditional Māori cultural knowledge and practices in a modern or contemporary context (O'Sullivan, 2006). Advocates of Māori indigenous rights have defined this implication as a form of 'indigeneity' (Durie, 2005; Hohepa, 2013; Mikaere, 2004; O'Sullivan, 2006).

In describing Māori as indigenous, Durie (2005, p.18) states that "the close and enduring relationship with defined territories, land, and the natural world, and exemplified by the pattern of Māori adaption to Aotearoa (New Zealand), it is possible to identify… characteristics of indigeneity." This statement is further described by Durie (2005) to represent his first and primary characteristic of indigeneity, which acknowledges the long-term connection indigenous people have with their environment. From a demographic perspective, Ngāti Whakaue is an iwi (tribe) predominantly located in the ancestral geographical boundaries of the small coastal settlement of Maketu and the city of Rotorua in the North Island of New Zealand (Stafford, 1967; Statistics New Zealand, 2006; Tapsell, 2000). Having a long, historical, enduring relationship with the physical natural environment is a fundamental characteristic of groups of indigenous people

(Kame'eleihiwa, 1992), and a typical defining feature for many groups of Māori (Durie, 2005; Walker, 1990).

Durie's (2005) further four characteristics of indigeneity also recognise a strong environmental bond. These include the formation of identity and cultural practices; knowledge systems, which encompass values and worldviews; the application of resulting ethos for economic growth and environmental sustainability; and language. Mikaere (2004) also agrees that Māori indigeneity is best expressed and managed by tikanga or protocol passed down from countless generations with a longstanding association with a particular area. Similar to other commentators about indigeneity (Durie, 2005; Penetito, 2010; Webber, 2008), Mikaere agrees that the expression of tikanga may change over time; however, fundamental values and principles will remain. Two examples of these principles are tika (being correct or right) in ensuring you enact a particular protocol correctly, and pono (being true or genuine) in making judgement of whether the enactment of a protocol is true to the principles of tikanga Māori (Mead, 2003). Tikanga Māori is essentially part of mātauranga Māori (the accumulated knowledge of generations of Māori) and Māori intellectual property (Mead, 2003).

In summary, Ngāti Whakaue identity, defined above and as used in this thesis, is not dissimilar from a traditional (Durie, 1998; Walker, 1990) and contemporary view (Penetito, 2010; Webber, 2008) of Māori identity, founded upon whakapapa or genealogical connections and strong connections with the physical environment (Carter, 2005; O'Malley & Armstrong, 2008; Penetito, 2010; Stafford, 1967). Ngāti Whakaue identity is distinct from other Māori tribes through unique waiata (songs), whaikōrero (formal speeches), pēpeha (introductions) and pakiwaitara (stories) (Carter, 2005; Mead, 2003; Mead & Grove, 2001; Stafford, 1999). Like other Māori tribes, Ngāti Whakaue identity has changed due to influences brought by European settlement (O'Malley & Armstrong, 2008; Walker, 1990) and continues to be situational and fluid (Penetito, 2010; Tapsell, 2000). Ngāti Whakaue claim their indigeneity through a long and enduring relationship with their ancestral geographical boundaries, and the practices, knowledge, values, resources and language associated with these parameters (Durie, 2005; Mikaere, 2004; Stafford, 1967; Tapsell, 2000). Application and expression of Ngāti Whakaue tikanga or protocol has changed and may continue to change (Penetito, 2010; Tapsell, 2000; Webber, 2008). However, fundamental principles will continue to be drawn from Ngāti Whakaue mātauranga or intellectual property (Mead, 2003; O'Malley & Armstrong, 2008). This concluding point about Ngāti Whakaue identity, the first aspect of Ngāti Whakaue culture, leads into the second aspect, Ngāti Whakaue and knowledge.

2.1.2 Ngāti Whakaue and Knowledge

There is evidence that many Māori and first European settlers embraced learning about each other's way of life, technology and knowledge in many areas, such as cultivation and navigation (Walker, 1990). Assimilative legislation has threatened the survival of mātauranga Māori, such as the Native Schools Acts of 1867 and 1871 and the Tohunga Suppression Act 1907, affecting multiple generations of Māori. The Native Schools Act expected schools to deliver a European-focused curriculum to many generations of Māori youth and the Tohunga Suppression Act punished tohunga, or usually Māori elders, for enacting their expertise in Māori knowledge (Rata, 2012). Despite a multi-generational loss of Māori knowledge due to these examples of harmful legislation and others, many groups of Māori have protected and continue to protect their unique bodies of knowledge.

Both Durie (2005) and Penetito (2010) acknowledge mātauranga Māori is founded on the relationship between Māori and their physical environment, born from lived experiences, observations and interactions. Their views are supported by Marsden (2003) who agrees that Māori knowledge also has spiritual dimensions in that it is handed down through generations. All agree that Māori knowledge, like Māori identity, is dynamic, situational and particularistic, with aspects of both theory and practice (Durie, 2005; Marsden, 2003; Penetito, 2010). A contextual view of mātauranga Māori is that it has been traditionally defined and shared by whānau (family), hapū (sub-tribes) and iwi (tribes) and continues to be disseminated in this way today (Penetito, 2010). Mātauranga Māori is defined by Royal (2012) as responding to three important questions: Who am I? What is this world that I exist in? What am I to do? (p.35). Similar to Penetito (2010), Royal (2012) states that the first question supports the individual in understanding themselves as part of a collective and the accumulated knowledge associated with tribal origins. The second question explores how traditional Māori knowledge offers a Māori perspective on understanding the world around us. The third question addresses how an individual chooses to apply mātauranga Māori in their own life, which supports the earlier arguments that Māori knowledge is dynamic and contextual (Durie, 2005; Marsden, 2003; Penetito, 2010).

Ngāti Whakaue identity and knowledge are interconnected because the history, stories and experiences that define who Ngāti Whakaue are, and how they perceive and engage with their world, are both aspects of identity and bodies of knowledge (Royal, 2012). Like other iwi Māori, Ngāti Whakaue mātauranga is contained in oral traditions of waiata, whaikōrero, pēpeha and pakiwaitara and shared by Ngāti Whakaue with Ngāti Whakaue in Ngāti Whakaue-defined spaces (Tapsell, 2000). Ngāti Whakaue mātauranga is also shared in written records collated by historians and academics for dissemination with others (O'Malley & Armstrong, 2008; Stafford, 1967; 1999; Tapsell, 2000). The late Rotorua-based historian, Don Stafford (1967) showed his respect for the mātauranga that was shared with him and suggested for others to do the same by stating:

> There are numerous stories which must be open to doubt in the form given by tradition. Chronologically, there are occurrences which, if they took place as tradition tells us they did, defy all laws of logic. And so the reader may find events taking place and certain individuals involved when it seems it could not be so. Under these circumstances the reader should feel free to draw [their] own conclusions. I personally prefer tradition in its original form with any and all its inaccuracies than an edited version to suit current tastes. (p.v.)

Stafford's (1967) view of the dissemination of mātauranga Māori advocates for maintaining the integrity of knowledge shared through stories, by respecting long-standing history and tradition associated with that knowledge. He also supported the importance of allowing different interpretations. This example of respectful dissemination of Māori knowledge by a non-Māori reflects Durie's (2005) interface approach, which recognises indigenous and non-indigenous knowledge systems as distinct, with aspects that are open for interpretation. The overall aim of this approach is to use these distinct aspects of each body of knowledge to benefit all.

In summary, like many other groups of Māori, Ngāti Whakaue have experienced loss of mātauranga Māori due to assimilative legislation (Walker, 1990). Ngāti Whakaue mātauranga originated from the relationship between the physical environment, lived experiences, observations and interactions, and has been passed on through many generations (Durie, 2005; Stafford, 1967; 1999; Tapsell, 2000). This thesis includes these features in its definition of Ngāti Whakaue knowledge, but also views it as dynamic because Ngāti Whakaue members will continue to interpret and engage with their world (Royal, 2012) and share through oral traditions, as well as new forms of technology. This asserts that the dissemination of Ngāti Whakaue mātauranga should be contained within Ngāti Whakaue protocol and preferably through the medium of the Māori language, which is the final aspect of Māori culture, as described in this research.

2.1.3 Ngāti Whakaue and Language

Traditionally, te reo Māori (Māori language) was a fundamental element of Māori culture and one example of taonga tuku iho or an inherited ancestral treasure (Penetito, 2010). Other important treasures included the social structures of whānau (family), hapū (sub-tribes) and iwi (tribes), as well as whakapapa or geneology (Penetito, 2010). Historically, the Māori language was how mātauranga Māori associated with particular tribes has been communicated and transferred through many generations, through oral practices, such as waiata (songs), ngeri (chants) and pūrākau (stories) (Hemara, 2000). Post European contact, many Māori were enthusiastic about written language, which was predominantly introduced to Māori by missionaries as a tool to convert to Christianity (Durie, 1997). Conversely, early European settlers learnt and spoke Māori, including missionaries who were the first written recorders of the Māori language (Durie, 1997). The decline in the use of te reo Māori as the main form of communication for Māori began post Treaty of Waitangi with assimilative legislation mentioned earlier, such as the Native Schools Act 1867 (Walker, 1990). This Act prohibited the use of te reo Māori in formal schooling, and for some Māori the limited use continued into the home, for varied reasons (Walker, 1990).

The decline of the use and understanding of the Māori language continued into the 1970s, until major efforts led by Māori to revitalise the Māori language began, most prevantly in schooling (Durie, 1998; Walker, 1990). One of the most significant initiatives was the creation of kohanga reo or early childhood focused language nests, with the first established in Pukeatua in Wellington in

1982 (Te Puni Kōkiri, 1999). Māori commitment to continue the revitalisation of te reo Māori through formal education led to the establishment of kura kaupapa Māori (Māori medium primary schools), wharekura (Māori medium secondary schools) and whare wānanga (tertiary institutions) (Te Puni Kōkiri, 1999). Te reo Māori has also become an official language of Aotearoa New Zealand through the Māori Language Act 1987, as a result of a 1986 Waitangi Tribunal case claiming te reo Māori as a taonga (Waitangi Tribunal, 1989). Prominent Northland Māori leader Sir James Henare's view that Māori language is the foundation of Māori culture was acknowledged as part of this claim (Waitangi Tribunal, 1989) by including his famous quote:

> Ko te reo te mauri o te mana Māori.
>
> *(The language is the essence of Māori existence.)*

This statement asserts that Māori language is an essential element of Māori culture; a unique indicator of Māori identity and the critical vehicle in the transferring of Māori knowledge.

Historically, Ngāti Whakaue encouraged their children to learn English and housed the first native school at Ohinemutu village in Rotorua (O'Malley & Armstrong, 2008). Like many other groups of Māori, Ngāti Whakaue supported their children learning the English language; however, like other Māori, they did not expect that this would be detrimental to their own language (O'Malley & Armstrong, 2008). Ngāti Whakaue have also participated in Māori-led Māori language revitalisation initiatives, through the establishment of kohanga reo, kura kaupapa Māori, wharekura and Ngāti Whakaue wānanga (gatherings) based on learning whaikōrero (speech-making), karanga (traditional call) and waiata (songs) (Cooper et al., 2003; Ngāti Whakaue Education Endowment Trust Board; 2012; 2013). Currently, the Ngāti Whakaue Education Endowment Trust Board funds at least five schools and early childhood centres with Māori language initiatives (Ngāti Whakaue Education Endowment Trust Board, 2013).

2.1.4 Summary

In summary, Ngāti Whakaue culture, as defined in this thesis, includes identity, knowledge and language, and, like many other groups of Māori, is founded upon whakapapa and their long-associated relationship with the physical environment (Carter, 2005; O'Malley & Armstrong, 2008; Penetito, 2010; Stafford, 1967). Ngāti Whakaue distinctiveness is described through waiata, whaikōrero, pēpeha and pakiwaitara (Carter, 2005; Mead, 2003; Mead & Grove, 2001; Stafford, 1999). Shifts in Ngāti Whakaue identity have occurred due to European settlement (O'Malley & Armstrong, 2008; Walker, 1990) and it continues to be situational and fluid (Penetito, 2010; Tapsell, 2000). For example, Ngāti Whakaue claim their indigeneity through their long-term relationship with historical lands and associated protocol, language and knowledge (Durie, 2005; Mikaere, 2004; Stafford, 1967; Tapsell, 2000). Ngāti Whakaue have experienced loss of mātauranga Māori (Walker, 1990), but knowledge is dynamic as Ngāti Whakaue members continue to observe and understand their environment (Royal, 2012). Similarly, Ngāti Whakaue reo has experienced a decline in speakers (O'Malley & Armstrong, 2008), language revitalisation initiatives are a focus area (Cooper et al., 2003; Ngāti Whakaue Education Endowment Trust Board; 2012; 2013).

As stated at the beginning of this chapter, Ngāti Whakaue is a core component of this research; hence the parameters of who Ngāti Whakaue are in regards to identity, knowledge and language have been described and defined. The next section of this chapter will define the other core focus of this research, science education.

2.2 What is Science Education?

As stated earlier, the second core component of this research is science education. This section will first provide a definition of the relationship between science and indigenous knowledge. A view of the aims and purposes of science education will then be provided. Science education will also be examined in relation to indigenous students, Māori students and culturally responsive schooling.

2.2.1 Science and Indigenous Knowledge

Tension between science education and Māori is mainly the result of the underachievement of Māori students in science education in comparison to non-Māori (Cowie, Jones & Otrel-Cass, 2011; Glynn, Cowie, Cass & Macfarlane, 2010; Kidman, Abrams & McRae, 2011). This is a similar situation for other groups of indigenous students around the world (Aikenhead & Michell, 2011; Bang & Medin, 2010; Brayboy & Castagno, 2008). There is increasing evidence that low positive participation levels of indigenous students, including Māori, in science education is due to the lack of recognition of indigenous culture in the science classroom (Aikenhead & Michell, 2011; Glynn et al., 2010). This tension is inherent in a larger issue, which is the contention that indigenous bodies of knowledge about our world are as valid as science bodies of knowledge (Durie, 2005; Kawagley, Norris-Tull & Norris-Tull, 2010; Roberts & Wills, 1998).

> Durie (2005) states that there are three main areas of debate between science and indigenous knowledge, which include: “opposition of science as the only valid body of knowledge; the rejection of science in favour of indigenous knowledge; the use of tools that are unable to unravel the essential nature of systems of knowledge” (p.18). There is no doubt that science is a dominant global knowledge system and has been defined as being devoid of bias, including culture, as stated by Roberts & Wills (1998):Western science is based on the premise that the ordered reality that exists independent of perception is universal and purely material, and that knowledge of this reality can be achieved only through systematic observation. Thus scientific conclusions are depicted as independent of any arbitrary biases, prejudices, or other subjective choices that may be made as a result of one’s cultural heritage, gender, ethnicity, or other factors. (p.56)

Others argue that scientific observations and analysis of data are susceptible to varied intepretations due to sociological factors, such as individual values and beliefs (Roberts & Wills, 1998). An elemental characteristic of many bodies of indigenous knowledge is a value-laden and holistic approach to observing, analysing and interpreting our physical environment that considers spiritual beliefs (Barnhardt & Kawagley, 2004). The inability for science to acknowledge our world as being anything more than a physically observable entity is in opposition to many indigenous peoples' views of the existence of intangible spiritual phenomena (Durie, 2005).

This thesis recognises these tensions between science and indigenous bodies of knowledge and endorses a complementary view of both knowledge systems as a means to support the positive engagement of Māori students in science education. Barnhardt & Kawagley (2004) acknowledged the agitations and complexities contained within the interface between science and indigenous knowledge. However, they also saw the potential of utilising the abundant knowledge, skills and perspectives contained in each body of knowledge as a means to improve the educational opportunities for indigenous students in their communities. This thesis also acknowledges science and indigenous knowledge as distinct, and that both can be drawn upon to meet the varied needs and opportunities for Māori students in science education. The recognition of science and Māori knowledge can be seen in the Aotearoa New Zealand science curriculum.

Aotearoa New Zealand has two science curriculum documents (Ministry of Education, 2007; 2008) to support students learning in either English or Māori medium classroom settings. The existence of two parallel curricula is an example of validating two cultural bodies of knowledge and provides all students the opportunity to learn science through the English or Māori language. The Māori medium curriculum (Ministry of Education, 2008) makes specific reference to making a difference for Māori and states it is aimed at providing learners with the “skills and knowledge to participate in and contribute to Māori society and the wider world” (p.3).

Both documents provide defintions of what is science, with the Māori medium curriculum, *Te Marautanga o Aotearoa* (Ministry of Education, 2008), stating:

> Science knowledge is a product of human culture, and belongs to all cultures. Science is knowledge about the natural world and the place of humanity in that world. It involves testing ideas against sensory experience of the world; it is flexible, fallible knowledge, which is continually reviewed and updated. Science knowledge is applied in developing the many types of technology in society. Science assists the Māori world to embrace the future. Linking together traditional and modern knowledge enables new knowledge bases to develop and be extended. A critical faculty is facilitated by the inclusion of a Māori world view. The student is able to develop his/her own ‘baskets’ or viewpoints on knowledge, as a foundation for studying those of other cultural origins. (p.53)

The *New Zealand Curriculum* (Ministry of Education, 2007) provides this definition:

> Science is a way of investigating, understanding, and explaining our natural, physical world and the wider universe. It involves generating and testing ideas, gathering evidence – including by making observations, carrying out investigations and modelling, and communicating and debating with others – in order to develop scientific knowledge, understanding, and explanations. Scientific progress comes from logical, systematic work and from creative insight, built on a foundation of respect for evidence. Different cultures and periods of history have contributed to the development of science. (p 28)

Both definitions state that the overall purpose of science is to continuously explore and understand our natural world in logical and systematic ways, in collaboration with others, to further develop scientific knowledge and new technologies. Both definitions also acknowledge the place of culture in the ongoing development of science. However, the Māori medium curriculum has a stronger focus, with specific reference to Māori culture and the valuing of students' viewpoints and backgrounds. This thesis chooses to define science through the key commonalities identified in the *New Zealand Curriculum* (2007) and *Te Marautanga o Aotearoa* (2008). These include the continued systematic and logical exploration of our world for future development to benefit all people, and recognising the place of culture, values and beliefs. The following sections provide definitions of how this thesis interprets the aims and purposes of science education, including for indigenous and Māori students.

2.2.2 Aims and Purposes of Science Education

One view of the purpose of science education is to prepare students for a science-related career, such as medicine, engineering or research (Boon, 2012), as well as produce students who will contribute to their community, national and global economic development (Ramirez, Lou, Schofer, & Meyer, 2006). In recent years, science education commentators described another main aim of the current science curricula, namely for students to be able to engage confidently with any socio-scientific issues they may become involved with in their lives (Boon, 2012; Cowie et al., 2011). A student's ability to use their science education to contribute positively to current issues is described as 'science literacy' (Osborne & Collins, 2001) and for some this is also a desired outcome of science education (DeBoer, 2000). Positive student engagement with science education, specifically their attitudes, interests and self-belief, is also viewed as an important aim that contributes to student involvement in science-related careers and projects (Woods-McConney, Oliver, McConney, Maor, & Schibeci, 2011).

These aims focus on science education as being important in equipping students with skills and knowledge to interact with science in society for themselves and their communities. Therefore, as reciprocal members of society, every student should have the opportunity for a science education that supports them to engage confidently with current science-related issues (Cowie et al., 2011). In his summary of historical definitions of the purposes of science education and meanings of scientific literacy, DeBoer (2000) states that:

> Ultimately what we want is a public that finds science interesting and important, who can apply science to their own lives, and who can take part in conversations regarding science that take place in society… Some will find the study of science compelling enough to pursue scientific careers; others will provide leadership regarding science-based social issues. The important thing is that everyone should have an opportunity to learn enough so they will not be left out of this dimension of our modern experience. (p. 598)

These aims are admirable due to their potential benefits and opportunities for students and their communities; however, it is how these aims are achieved that creates concerns about indigenous students (Eisenhart, Finkel, & Marion, 1996). Sutherland and Dennick (2002) described a key concern for indigenous students and science education is how the science curriculum is developed with limited consideration or total disregard for indigenous knowledge:

> Science curriculum is assimilative in its own right because it gives the impression the Western view of nature is the only legitimate way of learning about the natural world, thereby reducing indigenous knowledge to inferior and non-scientific. (p.2)

Aikenhead and Elliot (2010) agree that most school science programmes in industrial countries are focused on acquiring Western or Eurocentric knowledge and skills. They further assert that school science teaches what it is to be a scientist or possess a science identity based on Western beliefs and values with minimal recognition of indigenous perspectives of our world. Sutherland and Dennick (2002) add that it is the difference in how and why Western and indigenous knowledge is acquired that may hinder indigenous student engagement with school science. They argue that Western attainment of knowledge is about gaining commodity-earning access to power, where indigenous knowledge is earnt to be a contribution to the collective. Therefore, it has been difficult for many indigenous students to engage with science education as their worldview, values and identity have differed from the curriculum content and delivery of school science (Costa, 1995). For many indigenous students around the world the experience of science education is difficult, as their cultural worldviews and identities are scarcely visible in their programmes (Aikenhead & Elliott, 2010). Examples of some of these difficulties are described in the following section.

2.2.3 Indigenous Students and Science Education

Historically, education is just one area where colonial societies have attempted to assimilate indigenous peoples through teaching from a colonial worldview and ignoring an indigenous worldview (Aikenhead, 2001). Disparity in indigenous student engagement, participation, and achievement in education has occurred in all curriculum areas, including science education (Battiste, 2002). A key factor identified in the literature as contributing to the disparities in these areas for a range of indigenous students, including Māori, is the lack of inclusion of a student's culture in schooling. Battiste stated that many indigenous students did not engage well with mainstream schooling due to the unfamiliar culture of many educational institutions, rather than a lack of capability or intelligence. A report about Native Americans by the United States Commission on Civil Rights outlined that the educational achievement of Native American students in all basic learning areas was lower than any other ethnic group (U.S. Commission on Civil Rights, 2003). The Commission stated this was a result of: poor resourcing of facilities, teachers, curricula, and learning tools; discriminatory treatment; and the lack of Native American history and culture being included in schooling.

Indigenous Australian students also disengage from school in their senior high school years at a rate that is 30 per cent more than non-indigenous students (Ainley, Buckley, Beavis, Rothman, & Tovey, 2011). Racial discrimination and cultural alienation are factors linked to the disengagement of indigenous Australian students from schooling (Bodkin-Andrews, O'Rourke, Dillon, Craven, & Yeung, 2012). Other reasons suggested as to why indigenous students have disengaged from science classrooms are because the content did not have any relevant links to their own lives, and their indigenous knowledge was viewed as being inferior or invalid (Kawagley, Norris-Tull, & Norris-Tull, 2010).

Some science education commentators argue that science has its own culture, and a socio-cultural approach to science teaching and learning is beneficial for indigenous students (Aikenhead, 1997, 2001; Bang & Medin, 2010; Cowie et al., 2011). Moreover, there is the potential to engage and sustain student participation in science education if a student's indigenous culture is acknowledged in the science classroom (Aikenhead, 1997; Barnhardt &

Kawagley, 2004, 2005; McKinley, 2007; McKinley & Stewart, 2009; Woods-McConney et al., 2011). For example, in their retrospective analysis of Programme for International Student Assessment (PISA) data for Aotearoa New Zealand and Australian students, Woods-McConney et al. (2011) argued that indigenous students showed high engagement with contextual science learning. Their findings showed that the only area in which indigenous students engaged either the same or more than non-indigenous students was with contextualised science topics. This research does not clearly state that it was the cultural content of contextualised science topics that supported high student engagement; however, relevance, and authenticity are argued as elements that improved indigenous student engagement (Woods-McConney et al., 2011). Examples of relevant and authentic components such as links to home life, community, culture or identity were promoted by this study (Woods-McConney et al., 2011).

Cowie et al. (2011) were clearer about the benefits of including cultural knowledge with science education in their study examining student notions of identity in science to enhance participation and engagement. They reported that Māori students responded positively to their science learning when teachers encouraged them to share their own knowledge as well as involve their families and wider community. More specifically, Māori students engaged with opportunities to share cultural knowledge such as local Māori history, stories and perspectives about their immediate community. In this study there were examples of Māori students willing to access and share cultural knowledge from their families and communities as part of their science learning.

The diversity of indigenous science students also needs to be considered if culture is to be an important component of the science classroom. Indigenous student learning preferences are diverse, and the same is true for Māori students (Hill & Hawk, 2000; McKinley, 2001). Māori student diversity is influenced by various experiences in different contexts and settings (Waiti & Hipkins, 2002), including interaction with their culture and affiliated tribes. Costa (1995) provided an example of the diversity of indigenous science students through descriptions of how easy it might be for an indigenous student to transition between their indigenous culture and the science classroom culture. One description included the 'potential scientist', meaning this particular type of indigenous student was able to transition naturally and smoothly between their own culture and engage positively with the culture of science education in the classroom. In contrast, another description was the 'inside outsider', or an indigenous student who finds it impossible to engage positively with science education because of alienation or discrimination in the school setting, despite the student showing evidence of a high interest in their immediate natural environment (Costa, 1995). These descriptions can also be applied to Māori science students, with many experiencing the latter in the school setting (Bishop & Berryman, 2006; Bishop & Glynn, 1999; Bishop, Berryman, Tiakiwai, & Richardson, 2003).

These characteristics of indigenous student diversity are reflected in the science education aims outlined earlier in this chapter. The 'potential scientist' (Costa, 1995), or the indigenous student who engages easily with school science, is an example of the student who could meet the science education aim of achieving a traditional science career (Boon, 2012). This type of student could potentially contribute to their community's economic development while maintaining a connection with their culture (Ramirez et al., 2006). The 'insider outsider' indigenous student who does not engage easily with the science classroom could be supported by the other main purpose of science education which is to engage students confidently with current socio-scientific issues applicable to their immediate environment, including physical and cultural aspects (Boon, 2012; Cowie et al., 2011). This purpose focuses on equipping students with skills and knowledge to interact with science in society for themselves and their communities.

The New Zealand science education community has similar aims to those identified above (Office of the Prime Minister's Science Advisory Committee, 2011). In alignment with their international counterparts, New Zealand science education commentators also identify that one of the main purposes of science education is to prepare students for tertiary education focused on traditional science careers (Boon, 2012; Office of the Prime Minister's Science Advisory Committee, 2011). They also agree that it is important to build students' science literacy to engage confidently with science-related debates and issues (Boon, 2012; Bull, Gilbert, Barwick, Hipkins, & Baker, 2010; Cowie et al., 2011). Two other broad purposes for science education in common with international thinking were identified, which are equipping students with the practical knowledge of how things work and developing skills to critique and analyse information (Bull et al., 2010).

Māori science education commentators agree that science education should be aimed at developing scientifically literate students who have the opportunity to participate and contribute to their society (McKinley, 1997; McKinley et al., 2004). Science education aims should provide opportunities for Māori students in New Zealand (Cowie et al., 2011) to contribute to a wide range of science contexts that could further develop Māori communities (McKinley, 2005; McKinley et al., 2004; Waiti & Hipkins, 2002). Outcomes of science education seen as desirable by Māori include economic development, environmental sustainability, equitable access to science research systems, the retention of traditional knowledge, managing the interface between science knowledge and Māori knowledge, and representation in public science (McKinley et al., 2004).

The *New Zealand Curriculum* (Ministry of Education, 2007) attempts to address all of these aims in the description of the purpose of the science learning area**:**

> In science, students explore how both the natural physical world and science itself work so that they can participate as critical, informed, and responsible citizens in a society in which science plays a significant role. (p. 17)

The majority of Māori students learn science in an English medium setting based on this description. However, New Zealand also has a Māori medium learning pathway where school science has been taught from the Pūtaiao (Science) Māori medium curriculum document (Ministry of Education, 1996) and the Pūtaiao section of *Te Marautanga o Aotearoa* (Māori medium curriculum framework) (Ministry of Education, 2008). The purpose of learning Pūtaiao is similar to that of the *New Zealand Curriculum* for the science learning area (Ministry of Education, 2007) as stated in *Te Marautanga o Aotearoa* (Ministry of Education, 2008):

> The student will gain competence in (science skills)… develop science literacy as well as physical, ethical and cognitive competence. Access to the highest professional levels in the world of science is imperative, as is retaining respect for the natural environment. (p. 53)

2.2.4 Māori Students and Science Education

As described in the previous section, Māori students can choose to learn science in either an English medium or Māori medium classroom setting. Both settings have had varied results for Māori students and their achievement in science education in New Zealand (McKinley et al., 2004; Stewart, 2011). Māori student achievement in science has recently been reported internationally in a summary of the New Zealand results in the Trends in International Mathematics and Science Study (TIMMS), 1994–2011, where Māori students had significantly lower scores than non-Māori (Caygill, 2008; Chamberlain & Caygill, 2012). Nationally in the nineties, a comparison of the results of the ‘Science in everyday contexts’ sections of the New Zealand National Education Monitoring Project (NEMP), 1995 and 1999, revealed two areas of progress for Māori students (Waiti & Hipkins, 2002). The first example was the significant improvement in Māori student results in completing practical tasks correctly (Flockton & Crooks, 2000). Reasons behind this improvement were not investigated further at the time, but they were noted. However, Waiti and Hipkins (2002) suggested that Māori students may have engaged more positively with assessment tasks based on everyday experiences. The 2003 (Crooks & Flockton, 2004) and 2007 (Crooks, Smith, & Flockton, 2008) NEMP reports have reinforced this finding as Year 4 Māori students completed the practical assessment tasks as well as non-Māori; however, non-Māori students achieved moderately higher results than Māori students in all other areas of assessment tasks. These comparisons suggest that Māori student engagement and achievement in science activities may improve if tasks have relevance or connection with their own lives. Cowie et al. (2011) agree that science learning experiences that acknowledge student background knowledge and out-of-school and home experiences support positive Māori student outcomes in science education.

The second positive shift observed in the NEMP study (Flockton & Crooks, 2000) was that a higher proportion of Māori students learning in Māori medium environments had a more positive view on their abilities in science than their peers in English medium settings (Waiti & Hipkins, 2002). Māori medium learning environments are based on Māori philosophies and practices (Ministry of Education, 2010b), so this finding suggests that learning science in a context that has links with Māori culture could have a positive result for Māori students in science education (Waiti & Hipkins, 2002). The 2003 (Crooks & Flockton, 2004) and 2007 (Crooks et al., 2008) NEMP reports revealed there was no significant difference between Māori and non-Māori students' attitudes and motivation towards science. However, in their recent study Cowie et al. (2011) agreed that the inclusion of Māori cultural knowledge in the science classroom was beneficial for both students and teachers. Their review of four assessment studies in New Zealand found that the main challenge for some teachers was their concern about their lack of knowledge of Māori culture. However, they also found that Māori students were enthusiastic to access and share their own and others' knowledge of a Māori perspective in their science classroom.

Some authors argue that Māori participation and performance in science education is undermined through low teacher efficacy and expectations, inadequate teacher content, pedagogic and cultural knowledge, and a rigid curriculum framework that creates little space for Māori determined pedagogy (Hill & Hawk, 2000; McKinley, 1996). These issues occur in both English- and Māori medium school science settings in New Zealand. In Māori medium education, for example, issues include limited numbers of qualified teachers with specialised science content knowledge and Māori language proficiency, as well as Māori content knowledge applicable to science education (Stewart, 2011). English medium teachers face similar challenges, including the limited availability of credible Māori resources and support to teach Māori content knowledge, differences in cultural views and values, and students possibly knowing more than their teachers (Howe, 1997).

The inclusion of the students' indigenous languages by science educators in their classrooms is advocated as an example of culturally responsive pedagogy, as understanding an indigenous language also involves understanding of cultural practices and knowledge (Aikenhead, 1997, 2001; Bishop & Glynn, 1999; McKinley, 2001; Waiti & Hipkins, 2002). Explaining a science term in the Māori language can sometimes support a student's understanding of the concept (Harlow, 2003). For example, 'hāora' is the Māori term used for 'oxygen'. The meaning and function of 'oxygen' can be difficult to decipher as it originated from various languages. The Māori term can be understood by breaking the term into 'hā', meaning breath, or to breathe, and 'ora', meaning life source. A key challenge for both English and Māori medium science classrooms is the small number of qualified science teachers fluent in the Māori language, especially at a secondary school science level (Stewart, 2011). This challenge limits student access to a wide range of science subjects and creates pedagogical issues for teachers. Poor teacher content knowledge, limited teacher capability, and constrained access to resourcing, add to the difficulty for teachers in meeting the diverse needs and identities of their students.

In the New Zealand context, Māori student learning preferences are as diverse as those of any other ethnic group (Hill & Hawk, 2000; McKinley, 2001). There is no one way to 'be Māori', given that individuals are influenced by diverse experiences in different contexts and settings (Waiti & Hipkins, 2002). Diverse experiences could include the amount of interaction they have with Māori tribal communities, their school setting, and their knowledge of Māori culture. Many Māori families live away from their tribal communities for many different reasons. This means Māori student engagement with their affiliated tribes can be intermittent, limited, or they may have no connection at all. This diverse range of engagement with Māori tribal communities can have varied effects on Māori students. Whether Māori students learn through the medium of the Māori language or in an English medium learning environment also contributes to the many facets of being a Māori student. Māori student knowledge of supposed ‘Māori’ science topics, such as ‘Hangi – Māori cooking method’ and ‘Rongoa – Māori practices in medicine’, can range from no experience to having more knowledge than their science teacher (Hipkins, Joyce, & Bull, 2000).

In summary, common broad science education aims have included preparing students for a science-related career (Boon, 2012) that could involve them in contributing to their local, national and global communities (Ramirez et al., 2006), and for students to engage confidently with any socio-scientific issues (Boon, 2012; Cowie et al., 2011). DeBoer (2000) also states that contributing to the proposed outcomes of these aims may not appeal to all; however, it is important for all students to have an opportunity to be part of science programmes that cater for their own and others’ interests. Some common critical issues and possible strategies were also identified through examining recent indigenous student (Aikenhead, 2001; Ainley et al., 2011; Bodkin-Andrews et al., 2012) and Māori student achievement and engagement with science education aims (Chamberlain & Caygill, 2012; Cowie et al., 2011; Waiti & Hipkins, 2002). The overall issue was the low achievement of indigenous students in science education which, it has been argued is possibly due to the minimal visibility of indigenous culture in the science classroom.

In their exploration of New Zealand and Australian student science engagement and literacy, Woods-McConney et al. (2011) found that positive indigenous student engagement with science education occurred when science learning was authentic and relevant. For Woods-McConney et al. (2011), authentic and relevant science learning, involved promoting student autonomy and the exploration of students' lived experiences, interests and concerns, including links to aspects of indigenous culture. Possible strategies to address the low achievement and engagement of indigenous students in science education have included the need for science teachers to engage with aspects of culturally responsive schooling. How this thesis relates culturally responsive schooling to science education will be explained in the following section.

2.2.5 Culturally Responsive Schooling and Science Education

Culturally responsive schooling has been defined as including, "curricula and pedagogies (that) reflect multicultural rather than monocultural or dominant-culture perspectives" (Hindle et al., 2011, p.27). The New Zealand education system is predominantly monocultural, reminiscent of a European colonial history, catering for the majority non-indigenous student body, failing minority indigenous students (Bishop, Berryman, Cavanagh & Teddy, 2007). Culturally responsive schooling also includes culturally responsive classroom management (Savage, 2010), culturally relevant pedagogy (Ladson-Billings, 2001) and culturally responsive teaching behaviours (Gay, 2010), that examine a teachers' ability to acknowledge and respect the cultures of all of their students in their classroom practice (Savage, 2010). One of the main aims of culturally responsive schooling is for teachers and schools to implement programmes that reflect the culture of all students and to address disparities in educational opportunities for students' whose culture is not typically recognised (Castagno & Brayboy, 2008). This aim described above outlines how this thesis defines culturally responsive schooling.

This research examines the potential of culturally responsive schooling, as the aim was to explore whether indigenous community-based science education programmes could be a possible approach, to meet the needs of Māori science students in one particular Māori community. Research examining the actual experiences and perceptions of those involved in science education within an indigenous community, and in particular a Māori tribal context, is minimal.

Indigenous community involvement in school science, assumes the inclusion of indigenous culture, as part of what is being delivered (curriculum content) and how it's being delivered (pedagogy). The insertion of indigenous perspectives and understandings into science education is an example of culturally responsive schooling (Castagno & Brayboy, 2008) that has the potential to improve educational outcomes for indigenous students (Hindle, Savage, Meyer, Sleeter, Hynds & Penetito, 2011). Indigenous community-based science education programmes align with aspects of culturally responsive schooling which will be explained in the following section. The explanation of what elements contribute to a successful indigenous community-based science programme is also the next major component of this literature review.

2.3 Indigenous Community-based Science Programmes

Māori students' positive engagement with science education in New Zealand can contribute to a wide range of science contexts, which could benefit and provide opportunities for Māori students and their communities (Cowie et al., 2011). Science programmes that make connections with Māori students' culture, knowledge, and lived experiences and empower students to explore issues, questions, and solutions relevant to themselves have been shown to positively engage Māori students (Glynn et al., 2010). The exploration of local and current issues may assist tribal development priorities (McKinley et al., 2004), natural resource management (Moller et al., 2009), and the maintenance and protection of Māori knowledge (King, Skipper, & Tawhai, 2008).

Globally, science education that is focused on the needs of indigenous students can serve pragmatic outcomes for some indigenous peoples, including economic development, environmental responsibility, and cultural survival (Aikenhead, 1997). Indigenous peoples' knowledge and traditional practices can make a significant contribution to contemporary understandings of science (Barnhardt & Kawagley, 2004). For example, global science projects that incorporate diverse cultural views about the knowledge products and learning processes of science can allow new knowledge and understandings to emerge (Waiti & Hipkins, 2002).

There is evidence that indigenous community-based science education programmes have contributed to the positive engagement of indigenous students with science education (Aikenhead, 2001; Barnhardt & Kawagley, 2005). More detail about these programmes and their relevance to Māori students will be explained further on in this literature review. These programmes were aimed at providing a complementary combination of indigenous knowledge and culture, as well as the current science curriculum. Another important aim was to provide quality science learning experiences for indigenous students which historically were not common (Aikenhead & Elliott, 2010; Barnhardt & Kawagley, 2005). These science education initiatives have provided positive results for indigenous students, where students, teachers, schools, and indigenous communities have worked alongside each other, towards achieving shared outcomes (Aikenhead, 2001; Barnhardt & Kawagley, 2005).

2.4 Principles of Indigenous Community-based Science Education

Formal education systems have historically not met the needs of indigenous students in science education, so solutions have been sought from schools, universities and educators working with indigenous communities (Aikenhead, 2001; Barnhardt & Kawagley, 2005). Indigenous community-based science education programmes have shown improved academic results for indigenous students where schools have worked alongside members of local indigenous communities and other supporting agencies (Aikenhead, 2001; Barnhardt & Kawagley, 2005). Other achievements for indigenous students and their communities have also included improved student attendance, increased student interest in science and mathematics careers, and increased indigenous community involvement in science and mathematics education (Barnhardt, 2005).

Research already exists about how examples of indigenous community-based science education programmes operate and the resulting benefits, opportunities and challenges for indigenous students and their communities (Aikenhead, 2001; Barnhardt, 2005; Barnhardt & Kawagley, 2005). There is also research about the factors that support the successful facilitation of indigenous community-based education (Bishop 1996; May, 1999; Nee-Benham & Cooper, 2000) that may be applicable to the science education setting. Examples of successful programmes where schools have worked alongside members of local indigenous communities and other supporting agencies to identify what contributed to their success were examined for this literature review and the factors contributing to their success identified.

A seminal long-term operating indigenous community-based science programme was used as the exemplar to begin identifying possible key factors that contributed to the successful positive engagement of indigenous students with science education. This example was the Alaska Rural Systematic Initiative (ARLI), a collaborative project aimed at improving educational outcomes of Alaska Native students, involving the University of Alaska Fairbanks, the Alaska Federation of natives and the National Science Foundation and almost 200 rural schools (Barnhardt & Kawagley, 2005). This project has operated since 1995 and has served a minimum of 20,000 Alaska Native students since its inception. The rationale for choosing this initiative as an exemplar was because it is a current national project that continues to successfully support indigenous students, teachers, schools and their communities.

Literature describing the ARLI project was sourced (Alaska Native Knowledge Network, 1998; Barnhardt, 2005; Barnhardt & Kawagley, 2005; Battiste, 2002; Castagno & Brayboy, 2008) and first examined by identifying broad themes (Mutch, 2005) contributing to successful outcomes for indigenous students. Next, these initial themes were refined (Mutch, 2005) by examining if and how they considered indigenous culture, including identity, knowledge and language to reveal possible aspects of cultural responsiveness. A draft set of principles were collated from the analysis of this one initiative, ready to examine other possible examples of indigenous community-based community science programmes. The main criterion for finding further literature, about possible examples of similar programmes, was research involving indigenous peoples, including students and their communities, working in collaboration with school science programmes.

Analysis revealed a summary set of principles common across programmes. The principles identified are: partnerships and power-sharing strategies; shared values and aspirations; culturally responsive pedagogy; resourcing; collaboration; and local context. These principles are elaborated in the following sections along with examples describing successful indigenous science education programmes including those in New Zealand.

2.4.1 Partnerships and Power-sharing

A relationship has been identified between indigenous student positive engagement with school science and the autonomy to direct their own learning in partnership with their teachers (Woods-McConney et al., 2011). In their retrospective analysis of PISA data for Aotearoa New Zealand and Australian students, Woods-McConney et al. found that students saw self-directed, practical activities as beneficial for their science learning. However, students identified that these types of activities were those they least frequently experienced showing a lack of student autonomy. Student autonomy involves teaching strategies and teacher attitudes and beliefs that allow partnership and power-sharing with students (Bishop et al., 2007).

A New Zealand-based study of teacher and Māori student relationships identified that students reported they engaged less with teachers who dominated the classroom by instructing and controlling students (Bishop et al., 2007). In this same study students shared that this approach to teaching allowed them limited input into their learning and opportunities for their prior knowledge to be recognised such as their cultural background (Bishop et al., 2007). Research in the area of indigenous science learning has identified that indigenous students engage with school science when their cultural perceptions of science concepts are acknowledged by teachers (Snively & Corsiglia, 2001).

In his work with teachers and indigenous communities in Canada, Aikenhead (2001) observed positive results for students when teachers involved local indigenous elders and their knowledge about the immediate environment as a fundamental part of the science teaching unit. Students and teachers were learners together, which modelled power-sharing and life-long learning. Local elders and other members of the local community with specialised knowledge were seen as teachers also.

In their review of literature about North American indigenous communities' perceptions of science learning, Brayboy and Castagno (2008) identified a common partnership and power-sharing teaching strategy. This strategy suggests that to engage indigenous students in science, teachers need to act as 'cultural brokers' (Aikenhead, 2001). Teachers would need to view science knowledge as a cultural body of knowledge. This strategy would also involve teachers first identifying, then learning about their students' culture. Science learning experiences would acknowledge teacher and student cultural backgrounds and prior knowledge. Students would also have an opportunity to debate and explore the power relationships between indigenous knowledge and science (Brayboy & Castagno, 2008).

In their observations of indigenous Alaskan communities, Kawagley et al. (2010) reported that local indigenous elders wanted their children to be provided with science programmes that included a wide range of learning experiences delivered in partnership with schools and indigenous communities. Teachers also promoted a common indigenous view about the interrelatedness of people with their immediate physical environment, which is another example of partnership and power-sharing as humans are caretakers rather than directors of the environment. Brayboy and Castagno (2008) summarise that it is not the role of the school to teach the indigenous culture or language of the local community; however, it is the role of teachers, curricula and schools to develop and maintain an intimate relationship with the local indigenous community. The shared benefit is the production of indigenous students who are “academically prepared, connected to and active members of their tribal communities, and knowledgeable about both the dominant [culture of their school] and their home cultures” (Brayboy & Castagno, 2008, p. 734).

In Glynn et al.’s (2010) New Zealand-based project, one teacher described how they asked students to assist with the preparation of a class trip for themselves and a junior class. The students gave suggestions of what content they were to learn in relation to the culture of local Māori who were situated in the class trip location. This showed the teacher sharing management and teaching decisions with their students, and positioned other community members as teachers. Students were also encouraged to ask their own learning questions and the teacher’s role was to provide the resources. McKinley et al. (2004) agree schools and Māori communities working together to teach science also models to students that Māori knowledge is an integral part of their science learning and not an addition.

Wood and Lewthwaite’s (2008) study about Māori science education aspirations and realities in Māori medium classrooms showed how one Māori medium school decided to separate their Māori medium science learning environment from their English medium science classroom, and provided different teachers and a different subject name. Parents and wider family members were all included in the planning and content of their children's science learning. One teacher commented that the focus was on providing a balanced view of science and Māori knowledge in the science classroom and to not privilege one body of knowledge over another. The teacher also stated that the Māori worldview was the foundation and that the science perspective supported student understanding. A final comment from this teacher was that an important aim of their science programmes was to model that Māori have always engaged in activities labelled as science activities, long before Europeans came to Aotearoa New Zealand.

In summary, partnerships and power-sharing is the first principle of an indigenous community-based science programme identified from common themes in exisiting indigenous student science education programmes. This thesis defines this principle as students, teachers, schools and indigenous communities, as all being part of the decision making of what is included in science education programmes.

2.4.2 Shared Values and Aspirations

School organisational change, especially when schools come to acknowledge both Western science knowledge and indigenous knowledge in their science programmes, has also supported positive engagement from indigenous students in science education (Cobern & Loving, 2001). In his project, Aikenhead (2001) asked the local community what they wanted in their science programme, which resulted in the inclusion of local knowledge from indigenous elders and Western science content. This approach recognised indigenous knowledge as a valid and fundamental component for each science teaching unit, alongside Western science concepts (Aikenhead, 2001). Barnhardt (2005) reported that, in his experiences with Alaskan communities, the inclusion of cultural core values was an important component of education initiatives. Having an understanding of the values of their own culture and other cultures' allows all students the opportunity to engage, interact, and critique a wide range of knowledge systems (Barnhardt, 2005).

Brayboy and Castagno (2008) agree that the epistemological and socio-cultural views of an indigenous community need to be acknowledged and included in a successful indigenous science programme. In Aikenhead's (2001) project about collaborative units, the objective nature of Western science was made explicit and the physical environment was explored separately to gain new knowledge. In their discussion piece about differences between Western and indigenous science, Metallic and Seiler (2009) identified how indigenous cultures viewed physical and spiritual dimensions of the environment as being interconnected. Aikenhead (2001) stated that indigenous practices in regards to the sustainability of physical resources involved spiritual and cultural values unique to a particular indigenous community and their environment. Brayboy and Castagno (2008, p. 736) assert that when indigenous knowledge is included in a science programme, "the role of culture, subjectivity, and perspective in making sense of the world" is recognised.

Students involved in science programmes that worked collaboratively with local Alaskan indigenous elders learnt about correct processes to engage with local indigenous elders to see value in local indigenous knowledge and heritage (Barnhardt, 2005). Students collated interviews with elders about local indigenous knowledge systems and practices, and shared and extended what they learnt at regional and national science camps and fairs (Barnhardt & Kawagley, 2005). In Aikenhead's (2001) work with indigenous students in Canada, students reported that the opportunity to have their local knowledge included in their science learning also provided an opportunity to share the indigenous knowledge they had gained at home from their extended families. This practice saw their knowledge and their communities' knowledge as being valued in the science classroom.

In the New Zealand setting, McKinley et al. (2004) reported how a group of students from a Māori medium science classroom setting commented that the teacher's ability in delivering their programme in the Māori language was just as important as their content and pedagogical ability. Students also believed that the inclusion of Māori contexts in their science learning was only in the form of narratives and that valid content was from Western science bodies of knowledge. This is a difficult observation if an aim of Māori science education is for students to acknowledge both Māori and science knowledge as equitable (Stewart, 2011). Many teachers in Wood and Lewthwaite's (2008) study in Māori medium science classrooms were proactive about ensuring science knowledge was not privileged over Māori knowledge.

Furthermore, Glynn et al.'s (2010) study described how a teacher who aimed to enhance their students' understanding of Māori and science worldviews about environmental ecology and sustainability became more aware of the privileged position of science knowledge compared to Māori knowledge. The teacher organised their students to research information from a range of sources to ensure they were provided with a balance of Māori and science perspectives of sustainable practices. It was also reported that all teachers in this study worked toward ensuring that local Māori knowledge was respected at all learning sites, in and out of the classroom (Glynn et al., 2010).

In summary, this thesis defines the shared values and aspirations principle as the inclusion of an indigenous worldview in science education programmes, including cultural perspectives about identity, knowledge and language.

2.4.3 Culturally Responsive Pedagogy

The set of principles identified in this literature review are argued as being an example of culturally responsive schooling as they are aimed at implementing programmes that reflect the culture of all students and to address disparities in educational opportunities (Castagno & Brayboy, 2008). Culturally responsive pedagogy is part of the delivery of culturally responsive schooling and requires teachers to acknowledge and respect the cultures of all of their students in their classroom practice (Gay, 2010; Ladson-Billings, 2001; Savage, 2010). Culturally responsive pedagogy, practice and schooling have been promoted as key teaching approaches to improve the academic achievement and school engagement of indigenous students (Brayboy & Castagno, 2008). Research identifies that one of the main reasons why indigenous students disengage with science education is the lack of content or pedagogy that reflects their culture

(Abrams, Taylor, & Guo, 2013). The dominant culture of many science classrooms is viewed as Eurocentric (Aikenhead, 2011; Cowie et al, 2011), based on Western science principles that are sometimes in opposition to indigenous scientific views (Abrams et al., 2013). Curriculum content and pedagogy that make connections with the learner's culture (Bishop & Glynn, 1999) have been promoted as a way to engage indigenous students with science education (McKinley, 2005). Other social benefits for indigenous students include positive views about personal identity and constructive contributions to their communities (Brayboy & Castagno, 2008).

Indigenous students often interpret ideas about the world around them from their cultural background perspective based on values, knowledge, protocol, language, history and stories built from their communities' long-term relationship with a specific location or environment (Barnhardt, 2005). Therefore, a student's indigenous worldview often includes elements of their cultural background, knowledge and practices that need to be considered in the science classroom (Aikenhead, 2001). Sometimes what could be interpreted by a teacher as a student having a lack of understanding of a concept is actually a student having a different perspective. A student may disagree with the interpretation of a concept being taught in the science classroom and disengage with the learning (Snively & Corsiglia, 2001). Science classrooms where teachers and students are able to equally share their stories and experiences in relation to a science concept or topic support students to connect easily with the learning (Metallic & Seiler, 2009).

Aikenhead (2001) states that for successful integration of Western science knowledge and indigenous knowledge in cross-cultural science learning, units needed to clearly outline the local indigenous knowledge and the Western science knowledge as two worldviews or perspectives (Snively & Corsiglia, 2001). The focus in the programmes Aikenhead was involved with was on student understanding, but not to the detriment of one knowledge system through being assimilated into another, or for the student to wholly adopt either worldview. A successful strategy in Aikenhead's (2001) work was to begin a cross-cultural science unit with a clear indigenous knowledge framework outlining key concepts, ideas and values first, after consultation with local indigenous elders, as well as specifying the Western science foci. Similarly, a set of cultural standards was created to support the Alaska Rural Systemic Initiative, which provided clear guidelines on how resources could support the inclusion of local culture, knowledge and the environment into formal education programmes (Barnhardt & Kawagley, 2005). These clear guidelines and frameworks supported teachers with identifying the prior or lived knowledge that their students brought to the science classroom, including a broad range of ideas, beliefs, values and experiences (Snively & Corsiglia, 2001).

Understanding the indigenous language of students also supports understanding local cultural practices and knowledge (Aikenhead, 1997, 2001; Bishop & Glynn, 1999; McKinley, 2001; Waiti & Hipkins, 2002). Some translations of an indigenous term into another language may obscure or misinterpret the actual meaning and understanding for students and teachers (Aikenhead, 2001). The use of indigenous languages in the science classroom encourages students and teachers to explore different perspectives due to the varied structures of languages representing different worldviews (Metallic & Seiler, 2009).

Glynn et al. (2010) provided narratives from Māori and non-Māori teachers who participated in a project where they were encouraged to include Māori pedagogical strategies in their science teaching. The teachers shared their teaching role with local Māori elders and members of the wider community to support their teaching of Māori worldviews in science, and also learnt from their Māori students who brought their prior knowledge to the classroom (Glynn et al., 2010; Wood & Lewthwaite, 2008).

Wood and Lewthwaite (2008) reported in their research about Māori medium science classrooms that it was common for teachers to seek or be given support from other teachers with more science or Māori knowledge. This models to students that teachers are learners too, and that other people in the wider school community can also have the role of a teacher, including themselves and their wider family community. In another Māori medium setting, one teacher reported that in their own formal science learning they had not seen themselves in their studies and so separated being Māori from science knowledge (McKinley et al., 2004). This experience in their science education led them to choose to teach in Māori medium classrooms so that other Māori students were able to see Māori knowledge in science learning.

In summary, this thesis defines the culturally responsive pedagogy principle as practices that recognise the interchange of teacher student roles in science education programmes as a means to understand each others' cultural backgrounds and associated bodies of knowledge.

2.4.4 Resourcing

Funding from a range of sources was very important for the successful progress of indigenous community-based initiatives (Aikenhead, 2001; Barnhardt & Kawagley, 2005). Substantial funding allowed the production of teaching units to be shared with other schools and teachers within the community and provided capacity, capability, implementation and monitoring support. In his work developing cross-cultural science teaching units, Aikenhead (2001) saw the importance of having sufficient funding that provided time for teachers to be released to research, write and create resources. In his review of examples of indigenous community-based education, Corson (1999) also endorsed funding as key to administering professional development for teachers and community members as a means of strengthening community involvement and partnership.

Other important resource examples from the Alaska Rural Systemic Initiative included a website that collated examples of existing items to support the developing curriculum framework (Barnhardt & Kawagley, 2005). A national coalition was also established of science-focused providers' collated professional development and curriculum resources to support the implementation of the initiative aims. Development of new resources by participating teachers included community-based science curriculum resources and quality-assured units in partnership with local elders, as well as workshops focused on mathematics and science unit-building and performance standards (Barnhardt, 2005). Management of these activities included regional associations set up to manage each area's implementation and on-going development of the initiative and pedagogical practices (Barnhardt & Kawagley, 2005).

People resources were clearly important as previously mentioned, including local indigenous elders and other local advisors with knowledge unique and relevant to the culture of a specific community (Aikenhead, 2001; Barnhardt, 2005). Communication tools between people were therefore essential for a successful programme, such as newsletters, websites and regular regional meetings, which were used to disseminate the latest information, developments and materials (Barnhardt, 2005).

In Glynn et al.'s (2010) New Zealand-based research, accessing a range of resources, such as local conservation workers and specialised science laboratories, was an important aspect for one teacher in their science learning. Local Māori elders and members of the wider Māori community were also seen as valuable resources to offer knowledge about local stories and flora and fauna, and were accessed by all teachers involved in this research (Glynn et al., 2010).

In many Māori medium science classrooms, teaching science through the medium of Māori language and including Māori content and context are priorities; however, it is very difficult for teachers to manage. There are limited Māori medium science resources available to teachers and so extra research, planning and preparation, including translating, are common and onerous tasks (McKinley et al., 2004). Limited access to resources is of particular concern at the senior science level in Māori medium science classrooms, with limited teacher capability in specialised science and Māori knowledge, as well as lack of fluency in the Māori language (Stewart, 2011). Parents have moved their children from Māori medium to English medium as a result of this issue to allow their students access to wider science content knowledge and learning experiences (McKinley et al., 2004).

Wood and Lewthwaite (2008) reported in their research in Māori medium science classrooms that one Māori medium school used a teacher rotation system. Fluent Māori language-speaking teachers with both Māori and science knowledge were rotated around the school to support less knowledgeable teachers and their students. This is an innovative strategy to address one of the many diverse issues facing Māori science education.

In summary, this thesis defines the resourcing principle as the accessing of appropriate resources to ensure sufficient capacity, capability, implementation and monitoring support to include an indigenous perspective in science education programmes.

2.4.5 Collaboration

A key component common in successful indigenous community-based science education programmes is having students, teachers and schools working alongside indigenous communities (Aikenhead, 2001; Barnhardt, 2005; Barnhardt & Kawagley, 2005; Kawagley et al., 2011). One example of an indigenous community working collaboratively with a formal education system is described by the Alaska Rural Systemic Initiative (Barnhardt & Kawagley, 2005). The motivation for this initiative was for the Native Alaskan community to address past failures of outside endeavours to achieve the educational wellbeing of the Native Alaskan people in partnership with government education systems. The key outcome of this initiative was to promote both indigenous and Western knowledge as complementary elements of school curriculum and pedagogy. The application of this project reflected this outcome with key topics including 'Native Ways of Knowing and Teaching', 'Culturally Aligned Curriculum', 'Indigenous Science Knowledge Base', 'Elders and Cultural Camps' and 'Village Science Applications' (Barnhardt & Kawagley, 2005). Key facilitators of the initiative included education providers, indigenous community members, a university, and substantial funding from science- and community-focused organisations, which were co-ordinated by a national team.

Barnhardt and Kawagley (2004) stated that the inclusive national and regional management framework of their initiative allowed for clear and comprehensive systems, which contributed to affirmative reciprocal partnerships for all involved. A summary report evaluating the success of this initiative identified case studies that highlighted improved student achievement (Kushman &

Barnhardt, 1999). The report also stated that these case studies provided positive examples of indigenous bicultural and bilingual education aimed at meeting indigenous community needs and aspirations (Kushman & Barnhardt, 1999).

In his work in cross-cultural science teaching for indigenous students in Canada, Aikenhead (2001) was supported by science teachers, technical support people, local indigenous elders and other local community members to develop cross-cultural science teaching units. The aim of the project was to allow all students, including indigenous and non-indigenous students, to see relevance and meaning for them in science learning and to have a voice in what and how they learnt. The project progressed well when members met face to face and worked together in the community setting.

In New Zealand, some iwi are working in partnership with the government to improve Māori educational outcomes; for example, the Ministry of Education currently has a total of 57 agreements supporting iwi with initiatives focused on identity, cultural and language revitalisation (Ministry of Education, 2012). The main focus of these partnerships is to work alongside Māori parents, whānau (families) and iwi to achieve the current government-directed education intent of "Māori enjoying education success as Māori" (Ministry of Education, 2009, p. 11). One of the broad outcomes identified in the latest Māori education strategy *Ka Hikitia – Managing for success* is to see "Māori learners working with others to determine successful learning and education pathways" (Ministry of Education, 2009, p. 5).

There are increasing examples of Māori tribal groups working with science organisations (Cram, 2002; Ramstad et al., 2009) and Māori teachers participating in science professional development (Royal Society of New Zealand, 2013). However, there are limited documented examples of iwi, schools and science institutions working on projects collaboratively (McKinley et al., 2004), even though some may have done or may currently be doing so. The research explored in this section provides examples of schools working with their Māori communities on science projects.

Glynn et al. (2010) described how the process of constructing relationships with teachers, students, parents and Māori communities was the focus for a group of teachers aiming to include a Māori worldview in their science teaching. Teachers reported that a key result of this approach was the building of trusting and respectful relationships with their students. The collaborative assessment approaches described in their research included teachers and students modelling new learning to each other, having collective ownership of new knowledge gained and working together towards meeting the needs of their community. Wood and Lewthwaite (2008) also reported in their research with Māori medium science classrooms that input from parents and the wider Māori community was very important and was actively sought by some schools.

McKinley et al.'s (2004) research with students, teachers and parents in one Māori medium school found that all parents interviewed recognised that Māori knowledge could be included within the natural sciences; however, some saw science as an international subject, with the inclusion of Māori knowledge as not being very relevant. Some had moved or were planning to move their children to English medium schools for this reason, which was potentially difficult for students in shifting from a small, close family environment to a possibly larger school (McKinley et al., 2004). Māori parents may have viewed Māori content as irrelevant in the science classroom due to their own experience of science at school, where Māori content was not visible. Collaborative relationships between Māori communities, schools and science organisations could inform Māori parents about how Māori content in science education could provide opportunities for their children.

In summary, this thesis defines the collaboration principle as collaborative processes and systems to ensure the implementation of both indigenous and science bodies of knowledge in science education programmes.

2.4.6 Local Context

Globally, the indigenous communities' intimate knowledge of particular locations, because of their long-term inhabitation of these environments, is beginning to be valued by others who care for the sustainability of our natural resources (Barnhardt & Kawagley, 2005). Indigenous knowledge of the local natural world has recently been included in scientific studies based in Alaskan communities and explored as fundamental for school science programmes (Kawagley et al., 2010). Commentators on culturally responsive schooling have also advocated the importance of students having a good understanding of the indigenous language, culture and history associated with their immediate location to ensure the sustainability of the culture of the community (Alaska Native Knowledge Network, 1998). For indigenous students, culturally responsive schooling or pedagogy supports their learning by providing a connection between their cultural home environments that might not be the culture of their school (Brayboy & Castagno, 2008). It is therefore fundamental to identify appropriate knowledge that is associated with the culture of indigenous communities to ensure students have the opportunity to contribute to the maintenance of their particular community.

Science education scholars also agree that the most effective science curriculum needs to be connected to the local community (Aikenhead, 2001) and they need to work with indigenous elders and local community members, using local resources and participating in their activities (Brayboy & Castagno, 2008). In his description of a range of indigenous education initiatives, Barnhardt (2005) identified that pedagogy associated with place allows indigenous students to be taught through their culture and immediate location as a means of connecting with broader environments. Local indigenous elders and advisors have been identified as important contributors to the development and delivery of cross-cultural science units, providing support for teachers and students with their knowledge of local culture relevant to the context of the unit topic (Barnhardt, 2005). The most successful units, programmes and resources were those that considered the unique culture of a specific community, including language, culture, history and protocol. In some cases, this was also an opportunity for indigenous students to share their knowledge of the local cultural history and environment (Aikenhead, 2001).

Glynn et al. (2010) reported that students saw the importance of researching the stories and history of the local Māori people before visiting a new area. Their field trip focused on learning about landforms and a range of Māori tribal perspectives about the same landmarks. The students were reported as showing an interest in local Māori stories and science explanations about particular areas (Glynn et al., 2010).

An interesting argument about the value of including local Māori knowledge in the science classroom was given by a parent in McKinley et al.'s (2004) Māori-medium based project. The parent disagreed with local Māori knowledge being taught alongside science knowledge, as their child was not from the school area and it was the role of their own Māori tribal community to teach their children their affiliated Māori knowledge. This is an important issue for schools to acknowledge and recognises the diversity of Māori students that exists in diverse settings in New Zealand. Wood and Lewthwaite (2008), in their research in Māori medium science classrooms, reported that some teachers saw it as vital to include local Māori knowledge and learning experiences, as well as outside Māori community experiences, to promote the existence of varied Māori perspectives.

This thesis defines the final principle, local context as, the inclusion of local phenomena, including local indigenous communities and associated local issues in science education programmes.

In summary, this review examined some examples of indigenous community-based science programmes that have supported positive engagement of indigenous students in science education. A common set of principles has been identified which includes: partnerships and power-sharing strategies; shared values and aspirations; culturally responsive pedagogy; resourcing; collaboration; and local context. The purpose of identifying these principles was to establish the factors that contributed to the successful implementation and positive results of indigenous community-based science programmes. More specifically, the purpose was to explore approaches that Ngāti Whakaue and schools could use to develop, examine, and enhance community-based science programmes to benefit all involved, including students, teachers, parents and the wider community.

2.5 Conclusion

These principles resonate with a set of Kaupapa Māori theory principles (G.H. Smith, 2003). Comparisons between these principles between Kaupapa Māori theory and a recently proposed theoretical Kaupapa Māori science education framework will be made in the next chapter, which outlines the theoretical framework of this research. Links to Kaupapa Māori theory is necessary, as a focus of this thesis is to apply these principles to examine perceptions of science education within one Māori community, specifically Ngāti Whakaue. The aim is to develop Ngāti Whakaue community-based science programmes that could be considered for implementation by schools and other Māori and indigenous communities. There is minimal evidence of Māori community-based science programmes where schools, iwi and science organisations work together for shared outcomes. However, examples of school science programmes that make connections with Māori students' culture, knowledge and lived experiences are beginning to emerge (Glynn et al., 2010; McKinley et al., 2004; Wood & Lewthwaite, 2008). The following chapter aims to further examine the proposed principles of indigenous community-based science programmes as outlined in this review. These principles will contribute to the theoretical framework used to explore the focus of this research, which is to examine one Māori community's engagement with science education.

CHAPTER THREE – THEORETICAL FRAMEWORKS

3.0 Introduction

This chapter describes the theoretical framework for this study based on proposed principles identified in the previous literature review chapter that underpin successful indigenous community-based science education programmes. These principles include six components: partnerships and power-sharing strategies; shared values and aspirations; culturally responsive pedagogy; resourcing; collaboration; and local context. Due to this research being an exploration within a Māori community, focused on science education, these aforementioned principles are examined in relation to Kaupapa Māori research and Kaupapa Māori science education. Specifically, Graham Smith's commentary on Kaupapa Māori theory (G.H. Smith, 2003) and Georgina Stewart's views on Kaupapa Māori science education (Stewart, 2011) respectively. Place-based education theory will be introduced as a possible contributor to support the development and implementation of indigenous community-based science programmes.

First, a perspective of Kaupapa Māori theory will be provided, with links made to a view of Kaupapa Māori science education, and to the proposed principles from the literature review, to justify key components of the theoretical base of this research. Next, an overview of place-based education theory will be outlined, followed by a section describing place-based theory and its relationship to indigenous science education will be given. Links to the proposed principles are also made in the aforementioned section, to further validate both place-based education theory and the principles as parts of the theoretical framework of this study.

A figure will also be provided to show how Kaupapa Māori theory principles and Kaupapa Māori science education characteristics, the proposed principles of an indigenous community-based science programme, can provide the overarching theory for Māori community-based science programmes. Place-based education theory is included in the diagram as a mechanism that underlies teacher practice to positively engage Māori students in science education. Finally, how the theoretical framework could be used to explore the overall research question and context of this thesis will be explained.

3.1 Kaupapa Māori Theory

Kaupapa Māori theory stems from a Māori worldview, based on Māori epistemology, and incorporates Māori concepts, knowledge, skills, experiences, attitudes, processes, practices, customs, language, values and beliefs (Bevan-Brown, 1998; Bishop & Glynn, 1999; G.H. Smith, 2003; L.T. Smith, 1999). Kaupapa Māori theory is a form of critical analysis driven by Māori understandings and principles that contribute to transformative practice used by Māori communities as a deliberate means to comprehend, resist and transform issues (G.H. Smith, 2003, 2012). G.H. Smith (2003) espouses six principles in his interpretation of Kaupapa Māori theory that in practice could make a difference to the positive engagement of indigenous students in science education and, more specifically, Māori students.

Māori science education researcher Georgina Stewart (2011) advocates an approach to Kaupapa Māori science education that has characteristics similar to those described by examples of indigenous science education programmes (Aikenhead, 1997, 2001; Barnhardt & Kawagley, 2005; Brayboy & Castagno, 2008) and Kaupapa Māori theory (G.H. Smith, 2003). Stewart (2011) proposes a locally based critical science education that focuses on the sociology of science in a multicultural society, not a curriculum solely based on indigenous or Western science bodies of knowledge.

G.H. Smith's (2003) interpretation of Kaupapa Māori theory and Stewart's (2011) characteristics of a Kaupapa Māori science education are summarised in the following sections to highlight similarities with the principles identified from the analysis of the literature earlier in this chapter. A brief summary is provided in Section 3.1.7 showing those links. The main focus of this thesis is the investigation of one Māori community and its perceptions of science education. Hence, the proposed principles will be examined in relation to G.H. Smith's (2003) Kaupapa Māori theory principles and Stewart's (2011) characteristics of a Kaupapa Māori science education.

3.1.1 Tino rangatiratanga

G.H. Smith's (2003) first principle is 'tino rangatiratanga' or the 'self-determination' principle discussed in terms of sovereignty, independence, autonomy, self-determination and meaningful control over one's own life and cultural wellbeing. This principle represents Māori communities making decisions and choices about curriculum content, pedagogy and delivery. The first principle of an indigenous community-based science programme identified in this thesis, partnerships and power-sharing, also promotes indigenous communities making decisions about school programmes. The key focus of the partnership and power-sharing principle, like G.H. Smith's (2003) tino rangatiratanga principle, is to include students, teachers, schools and their associated Māori communities in decisions about 'what' is to be included in science education programmes.

These principles in practice allow students the right to be involved in decision-making processes, such as curriculum content and pedagogical choices (Bevan-Brown, 1998). In the science classroom, teachers could provide students and their families and wider community with opportunities to choose science topics and modes of assessment and delivery. School management structures could support teachers by ensuring policies and processes advocate teacher, student and community input into science education programmes (Foster, 2004).

Stewart (2011) proposed characteristics of a Kaupapa Māori science education include a critical approach to science education that explores history and science philosophy, specifically:

> a critical perspective on Western science – a critical science for Aotearoa New Zealand, which remains aware of its own limitations, and includes history and philosophy of science, while rejecting 'final form' (Duschl,

> 1990) and other scientistic representations of science in the curriculum. (p.735)

Stewart's (2011) first characteristic implies that science is seen as tentative, based on evidence that has been constructed from how an individual or group perceive 'final form'. Therefore it is important for those involved in the decision making about science curriculum content need to be open to varied and critical perspectives (McKinley, 1995). Like G.H. Smith's (2003) tino rangatiratanga principle and the partnerships and power-sharing principle identified in this thesis, Stewart's (2011) characteristic suggests the need for broad input into the development of science curriculum.

These principles and characteristic were evident in Glynn et al.'s (2010) study of teacher engagement with Māori concepts and science. This was shown when students assisted in the organisation and content of a science project that included local Māori culture (Glynn et al., 2010). These partnerships also model to students that Māori knowledge is an integral part of their science learning and not an addition (McKinley et al., 2004). Partnerships were also involved in Wood and Lewthwaite's (2008) study of Māori medium science classrooms. Parents and wider family members were involved in the planning and content of their children's science learning aimed at providing both science and Māori knowledge (Wood & Lewthwaite, 2008).

3.1.2 Taonga tuku iho

G.H. Smith's (2003) second Kaupapa Māori theory principle, 'taonga tuku iho' or 'cultural aspirations', asserts being Māori is both valid and legitimate, including the acknowledgement and inclusion of Māori language, culture and knowledge (Bishop & Glynn, 2000). In a school setting, this principle acknowledges Māori systems of knowledge, epistemology and pedagogy as being an integral part of classroom teaching and learning (Averill et al., 2009; Macfarlane, Glynn, Grace, Penetito & Bateman, 2008). The second principle of an indigenous community-based science programme identified in this thesis, shared values and aspirations, also promotes an indigenous worldview, including cultural perspectives, as being part of science education programmes. Like G.H. Smith (2003), this principle endorses the inclusion of aspects of Māori identity, knowledge and language in science classrooms.

These principles in practice, would see schools and Māori communities working together to ensure Māori knowledge is a critical component of curriculum development and pedagogy in science education. Teachers and students could have opportunities to include Māori knowledge and pedagogy as part of their science teaching and learning (Foster, 2004). The inclusion of Māori content and pedagogy in the science classroom could also cater for a wide range of student needs and abilities. The 'inside outsider' indigenous student would be supported, who struggles to engage with a prescriptive curriculum (Costa, 1995) that is removed from their natural world that the student belongs to. Part of their preferred learning approach could be to include content and pedagogy from their cultural background in their science teaching and learning.

These principles in practice could also support the indigenous student at the other end of the continuum, the 'potential scientist' who engages positively with the state-prescribed science curriculum (Costa, 1995). These students could be involved in internships working with indigenous communities and science institutions involved in collaborative projects as well as community-based science projects and initiatives.

Similar to G.H. Smith's (2003) taonga tuku iho principle that validates the inclusion of a Māori worldview in the science classroom, Stewart (2011) suggests that diverse cultural views are valid. This includes viewing science as a cultural construct based on predominantly Western values and beliefs (Aikenhead, 2000), and should be considered as a cultural persepective in science education programmes. Specifically she promotes, "an awareness of the importance of Māori philosophy, principles and practices including language and culture" (Stewart, 2011, p.735).

These principles and characteristic were evident in a project that examined Māori medium science learning experiences (McKinley et al., 2004). Students valued their science teacher's Māori language proficiency as much as their content and pedagogical ability. Similar to previous comments from some Māori parents, some students only saw Western science bodies of knowledge as relevant to their school science learning (McKinley et al., 2004). This is an important issue to explore if an aim of Māori science education is for students to acknowledge both Māori and science perspectives (Stewart, 2011). Glynn et al.'s (2010) study identified that the inclusion of Māori and Western science perspectives about a topic supports student awareness of the privileged position of science knowledge compared to Māori knowledge.

3.1.3 Ako

G.H. Smith's (2003) third principle, 'ako', promotes teaching and learning and originates from Māori genealogy protocol. For example, in its most basic form, ako occurs when both the teacher and learner can interchange roles and can learn and be taught by each other. The third principle of an indigenous community-based science programme identified in this thesis, culturally responsive pedagogy, also supports the interchange of teacher student roles as a means to understand each others' cultural backgrounds and associated bodies of knowledge. Like G.H. Smith (2003), this principle promotes opportunities where teachers and students share their knowledge and perspectives, and challenge each other's views.

In recent times, the education sector in New Zealand promotes ako as a pedagogical practice for reciprocal teaching and learning between student and teacher and students with each other as a means to draw on each others' prior knowledge (Bishop & Glynn, 2000). For many Māori the origin, understanding, and practice of ako are extremely complex with many variations dependent primarily on genealogy and tribal protocol (Pere, 1982). Therefore, the implementation of G.H. Smith's (2003) ako principle and the culturally responsive pedagogy principle promoted in this thesis would ensure these possible complexities would be carefully explored.

When describing her third characteristic of a Kaupapa Māori Science education, Stewart (2011) proposed that is is important for both science knowledge and mātauranga Māori to be recognised and stated there is a need for "an acknowledgement of the validity of science knowledge found within mātauranga Māori, i.e. a pluralist perspective on knowledge while rejecting radical epistemological relativism (Siegel, 2006)." (p.735). Similar to G.H. Smith's (2003) ako principle and the culturally responsive pedagogy principle identified in this thesis, Stewart (2011) implies that both science and Māori bodies of knowledge are important and valued.

These principles and characterisitic were evident in examples of teachers sharing their role with other teachers, Māori elders, the school community and their students as a means of including Māori content, and recognising their students' prior knowledge (Glynn et al., 2010; Wood & Lewthwaite, 2008). Some Māori medium teachers actively seeking opportunities to include Māori knowledge in science learning as they had not experienced culturally responsive approaches in their own science learning (McKinley et al., 2004).

3.1.4 Kia piki ake i ngā raruraru o te kāinga

G.H. Smith's (2003) fourth principle 'kia pike ake i ngā raruraru o te kāinga' or the socioeconomic mediation principle, acknowledges any socioeconomic disadvantages or difficulties that a group of Māori may be experiencing. This principle in practice aims to make sure a collective responsibility will come to the foreground to meet a need or find a solution to ensure overall wellbeing. For many Māori families, their children's schools are recognised as an important part of their community, therefore they will want to be a contribution wherever and whenever needed. The fourth principle of an indigenous community-based science programme identified in this thesis, resourcing, also promotes the accessing of appropriate resources to ensure sufficient capacity, capability, implementation and monitoring support to include an indigenous perspective in science education programmes. Both principles are focused on meeting an identified need through collective responsibility in the best possible way.

Macfarlane (2004) argues that teachers should also have a community role, which includes having an understanding of the context of the Māori community that inhabits the location of their school. Therefore, these principles in practice may include teachers working with Māori families and communities to learn local tribal history and stories, through to getting to know the backgrounds of specific families and students. For teachers, having this information can support clearer communication with their students and families, as shared knowledge indicates shared interest in supporting each other's needs (Macfarlane, 2004). In the science classroom, investigation topics could be based on local issues, and teachers and students could access local Māori history, stories and perspectives from local Māori families, tribes and organisations. Teachers, students and families could collectively, provide new insights into local issues, including both challenges and successes that could be a source of pride for the whole school community (Macfarlane, 2007).

Stewart's (2011) fourth characteristic of a Kaupapa Māori science education promotes the importance of having a political stance to legitimise a Kaupapa Māori approach to the delivery of science curriculum and ensure entitlement to government resources. Specifically, "a political stance mandated by the Treaty of Waitangi to underpin its legitimacy and entitlement to state resources (G.H. Smith, 1997)" (Stewart, 2011, p.735). Like G.H. Smith's (2003) kia piki ake i ngā raruraru o te kāinga or socioeconomic mediation principle, Stewart's (2011) characteristic requests the need for wider collective responsibility to meet the needs of Māori communities in regards to science education.

This characteristic and aforementioned principles were evident in Glynn et al.'s (2010) study about the inclusion of Māori concepts in science classrooms, as accessing a range of resources, including those from Māori and science communities, was important for some schools. Important issues prevalent in Māori medium settings, is the lack of quality resources and teacher capability (McKinley, et al., 2004; Stewart, 2011). This has led to some parents shifting their children to English medium schools (McKinley, et al., 2004); however, some Māori medium science teachers are exploring strategies to address the vital need for fluent Māori-language-speaking senior science teachers.

3.1.5 Whānau

G.H. Smith's (2003) fifth principle of 'whānau' or the extended family structure describes the cultural practices, values and customs that are organised around whānau and collective responsibility being a necessary part of Māori wellbeing and educational achievement. Collaboration is the fifth principle of an indigenous community-based science programme identified in this thesis and also promotes collaborative processes and systems to ensure the implementation of both indigenous and science bodies of knowledge in science education programmes. The key focus of the collaboration principle, like G.H. Smith's (2003) whānau principle, is the development and implementation of agreed structures to meet the needs of indigenous students in education, specifically indigenous science programmes.

In practice these principles would first recognise that Māori students, their communities and their specific needs in regards to wellbeing and achievement are diverse, therefore requiring diverse collaborative processes (Bishop et al., 2003). In the science classroom these principles in practice could involve the inclusion of individual and collective understanding of, contribution to, and direction of, a classroom topic or project (Foster, 2004).

Stewart's (2011) fifth characteristic of Kaupapa Māori science education views science as a product of cultural knowledge, subject to hybridity and interdependence due to the engagement with different cultural views, values and beliefs. Specifically:

> an awareness of processes of cultural hybridity and interdependence, and of science as a product of (multi)cultural knowledge, while rejecting the 'windowless monad' notion of culture (Moody-Adams, 1997). (p.735)

Stewart's (2011) reference to processes that involve 'cultural hybridity' and 'interdependence' implies that this characteristic embraces collaborative practices that consider diverse perspectives and collective responsibility. This characteristic links to the interdependent nature of G.H. Smith's (2003) whānau principle where education aims and implementation processes are decided by collective shared views that are complex and interchangeable.

These aforementioned principles and characteristic are evident in the New Zealand education system through partnership agreements with a range of iwi (Ministry of Education, 2012) and in education policy, which promotes Māori working with others to achieve education success as Māori (Ministry of Education, 2009). There is also evidence of iwi and teachers working with science organisations (Cram, 2002; Ramstad, et al., 2009; Royal Society of New Zealand, 2013). The research reported positive results from collaborative community projects such as teachers building good relationships with their Māori students and their communities (Glynn et al., 2010). One issue for some Māori parents arose when exploring collaborative approaches, where some parents questioned the relevance of including Māori content at all in their children's science learning (McKinley et al., 2004). A collaborative approach may support Māori parents in examining this issue and others in regards to science education for their children.

3.1.6 Kaupapa

G.H. Smith's (2003) final principle, 'kaupapa' or a collective philosophy, aims to ensure that Māori-centred initiatives within education are held together by a collective commitment and vision. It ensures such initiatives are connected with Māori aspirations to political, social, economic and cultural wellbeing, unique to specific Māori communities. The inclusion of local context is the final principle of an indigenous community-based science programme identified in this thesis, the inclusion of local phenomena including local indigenous communities and associated local issues in science education programmes. Therefore, both principles consider addressing locally identified issues applicable to a particular context or setting through local collective means.

These principles in practice were evident in student science projects about local landforms, including learning about local iwi perspectives (Glynn et al., 2010). There was evidence of some Māori parents not seeing the relevance of local Māori knowledge being taught alongside science content if their child was not from the area (McKinley et al., 2004). Despite this being a very limiting educative view, it does highlight the importance of recognising the diversity of Māori students.

Stewart's (2011) final characteristic of a Kaupapa Māori science education highlights the implications of balancing Māori language and science education aims in curriculum planning and delivery. Specifically:

> an awareness of the position of the Pūtaiao curriculum within language shift and change processes, and of the balance between aims in language planning and in science education. (p.735)

This characteristic links to the collective philosophical kaupapa principle (G.H. Smith, 2003), as decisions about the use of Māori language and curriculum aims should be made by specific local Māori communities. Māori language is a diverse phenomenon which occurs differently in the wide range of unique Māori communities (Stewart, 2011). This characteristic implies that the complex issues of the development of the Māori language and Māori student achievements should be managed and applied within individual local Māori communities. Local contexts including the physical environment, local issues, politics and history would all be a part of decisions about the inclusion of Māori language, content and pedagogy in science education programmes.

Similar to the previous principles and characteristics, research reported that some teachers saw it as vital to include local Māori knowledge and learning experiences to promote the existence of varied Māori perspectives (Wood & Lewthwaite, 2008).

In summary, examples of science education research involving Māori students and sometimes their communities have been linked to a set of Kaupapa Māori theory principles, the principles of an indigenous community-based science education idenitified in this thesis, and a set of theoretical characteristics of a Kaupapa Māori science education. The purpose was to identify whether there were any commonalities or relationships between the principles and characteristics to support the development of a Māori community-based science programme. Table 3.1 below displays a summary of the links between the principles of a successful indigenous community-based science programmes described in the research literature, a set of Kaupapa Māori theory principles, and characteristics of a proposed Kaupapa Māori science education.

Table 3.1: Shared principles and characteristics of a Māori community-based science programme

Proposed indigenous community-based science education principles identified from literature	**Kaupapa Māori theory (G.H. Smith, 2003)**	**Kaupapa Māori science education (Stewart, 2011)**
Partnerships and power-sharing	Tino rangatiratanga	Critical science
Shared values and aspirations	Taonga tuku iho	Māori worldview
Culturally responsive pedagogy	Ako	Validity of science and Māori knowledge
Resourcing	Kia piki i ngā raruraru o te kāinga	Political legitimacy
Collaboration	Whānau	Cultural interdependence
Local context	Kaupapa	Curriculum

In the following section, place-based education theory will be introduced as a possible contributor to support the development and implementation of indigenous community-based science programmes. First, an overview of place-based education theory will be given, and then a description of place-based theory and its relationship to indigenous science education will be outlined. Finally, links to the proposed principles will be made to further validate place-based education theory and the principles as important components of the theory based of this research.

3.2 Place-based Education Theory

Prolific place-based education commentator David Gruenewald (2005) reminds us that “before the development of common schooling in the 1800s all education was place-based” (2005, p. 263). Learning and teaching were based on the local context and culture of a particular location, and were focused on meeting the needs and sustaining a way of life in a community. For many countries, the industrial revolution changed societal focus from local to national and global participation and hence education systems became normalised (Gruenewald, 2005). This has been a similar experience for the education system in New Zealand; however, there is evidence that the native schools’ education system for Māori continued to operate, following place-based practices (Timutimu, Simon, & Morris Matthews, 1998).

Native schools operated in New Zealand from 1867 to 1969 with the intention of assimilating Māori into a dominant European culture (Timutimu et al., 1998), an experience shared by other indigenous people around the world (Kawagley et al., 2010). In many Māori communities native schools were very successful in their assimilative intentions, where curriculum content and delivery were based on non-Māori philosophies and outcomes (Timutimu et al., 1998). One of the most harmful effects of the operation of native schools was the decline in fluent speakers of the Māori language as its use was banned in many schools.

For many indigenous peoples this has resulted in the loss of unique knowledge and protocols, due to language being the foundation of all indigenous cultures (Kawagley et al., 2010).

For some, however, the native school policy in Aotearoa New Zealand was the best example of a structure that contributed positively to Māori students and race relations. There was evidence that some non-Māori native school teachers and Māori communities worked together to meet the needs of their students according to their particular context (Timutimu et al., 1998). This is an example of what Gruenewald (2005) terms as critical pedagogy of place, as the teacher's focus on meeting student and community needs was in opposition to implementing assimilative education policy.

Gruenewald (2003a, 2003b) has offered other terminology in the area of place-based education, including critical pedagogy of place and place-conscious education. Critical pedagogy of place combines the sociological issues of critical pedagogy and the ecological thinking and approaches of place-based education, with the main aim being to "ground place-based education in a pedagogy that is socially and ecologically critical" (Gruenewald, 2003a, p. 9). Place-conscious education aims to extend "notions of pedagogy and accountability outward toward places so that pedagogy is more relevant to individuals' lives and what they consider important" (Gruenewald, 2003b, p. 620). Finally, Gruenewald (2003b) states that place-based theory engages students, teachers and schools more intimately with social, political and environmental issues associated with their local setting, which in turn encourages responsibility and accountability.

Fellow place-based education commentator Gregory Smith (2002) described how one aim of place-based education: “to ground learning in local phenomena and students’ lived experience” (p. 585). G.A. Smith (2002) advocated that engaging students in the exploration of unique issues within their school and immediate community connects school learning with students’ own lives, knowledge, and experiences. Schools are often places where students are unable to use their life experiences and are unable to apply what they learnt at school to their everyday life (G.A. Smith, 2002). Place-based education offers an approach to teaching and learning that is relevant not only to environmental but also wider social issues associated with a particular location, such as indigenous and cultural perspectives.

Indigenous education commentators Ray Barnhardt and Oscar Kawagley (2005) advocate the importance of indigenous peoples’ knowledge and perspectives of ‘place’ in education and environmental sustainability issues. Barnhardt and Kawagley state that, “the depth of indigenous knowledge rooted in the long inhabitation of a particular place offers lessons to everyone, from educator to scientist” (p. 9, 2005). Many indigenous peoples have maintained their commitment to sustaining their worldviews, knowledge systems, values, beliefs and practices, despite significant social and political disruptive circumstances (Barnhardt & Kawagley, 2005). Similar to Gruenewald’s (2003b) ideas about invoking values of responsibility and accountability in place-based education, Barnhardt and Kawagley (2005) advocated the importance of shared responsibility between indigenous and non-indigenous communities.

An example of this sense of responsibility in practice is the intimate relationship that exists for many indigenous people between knowledge and land and how indigenous people see themselves as being part of nature rather than observers of nature (Whitt, Roberts, Norman, & Grieves, 2003). These strong bonds with the environment evoke a sense of responsibility for many indigenous people as both the human and natural world are seen as one and interrelated (Whitt et al., 2003). This is in contrast to a Western science view of nature where knowledge of and about nature is distinctly separate from nature itself and is more theory-laden whilst based on empirical data (Whitt et al., 2003). Indigenous knowledge and perspectives of the environment are beginning to be viewed by Western science communities as being valid and valuable. This is evident in the area of environmental sustainability where spiritual and intimate practices are considered as approaches to sustain natural resources (Barnhardt & Kawagley, 2005). This is an indication that more than empirical data is needed to understand the world around us.

Māori educationalist and New Zealand-based place-based education commentator Wally Penetito (2009) agrees that the most basic objective of place-based education is to "develop (and nurture) in learners a love of their environment" (p. 16). Some of the main themes of place-based education include "environmental studies, ecological studies, biodiversity, community education, school community relations, local history, and sustainable development" (Penetito, p. 6). These have emerged to address continuing societal and environmental issues including: 'separation from locality' or a detachment from a place due to familiarity; ‘ecological consciousness’ or overcoming this detachment; ‘connecting culture with community’ or working together for shared goals; and ‘breathing life into history’ or the recognition of local history as a fundamental part of meaningful learning contexts (p. 16).

Place-based education or place-based learning is similar to a range of traditional Māori philosophies and pedagogies that, if implemented in contemporary settings, could make a difference for Māori students (Penetito, 2009). One key example is that of ‘whakapapa’ or the unique Māori perspective of genealogy, where “everything has a whakapapa: every person, tree, stone, mountain, fish, plant, the earth, and the stars, absolutely everything that makes up the human, spiritual and natural worlds” (Carter, 2005, p. 8). In relation to this description, a lot of Māori see themselves as being intimately connected with the physical environment and have strong kinship ties to their geographical boundaries. A common practice of how Māori describe this relationship is through ‘pēpeha’ or an oral introduction of oneself through the sharing of one’s geographical boundaries. This is a form of sharing knowledge about the physical land and its resources, the human connection to it, and a practice of how to maintain and sustain the important reciprocal relationship between the land and people (Carter, 2005).

Story-telling and narratives that connect land with people is a practice shared by many indigenous people that provides vast sources of knowledge about places and a fundamental source of identity for people (Whitt et al., 2003). Māori traditional oral practices of story-telling include examples of whakapapa and pēpeha and describe the strong connection that many Māori have with the physical environment (Ministry of Education, 1992). Stories are filled with references to places and descriptions of how their names were given by ancestors to describe events, people, or the basic physical appearance of a location. Stories are a fundamental part of the Māori culture and many describe not only the historical and physical connection with a location, but also the spiritual, supernatural, economic and political, as well as cultural, connections (Ministry of Education, 1992). In many New Zealand schools and around the world, the school and its classrooms reflect the dominant culture of society rather than the culture of the students or school community. Penetito (2009) advocates that a teacher's knowledge of classroom practice also needs to include an understanding of local context, as well as student, content and pedagogical knowledge.

In his chapter about the importance of place in indigenous education, Kawagley (2000) described the need for schools to have a set of culturally responsive standards applicable to the local indigenous people and associated environment. The aim of the cultural standards was to encourage schools, teachers, students and the community to recognise and include the unique and rich contribution indigenous communities had to offer. Reciprocally, schools had the opportunity to make a contribution to their community as they focused on and explored issues applicable to their surrounding physical and cultural environments. The main benefit of these cultural standards is that they were created to be interpreted and implemented by each community to suit their particular cultural context, not inclusive, exclusive or conclusive. Unlike other common practices of national standards, the purpose of these standards was "to encourage schools to nurture and build upon the rich and varied cultural traditions that continue to be practiced in communities [throughout Alaska]" (Kawagley, 2000, p.109). A fundamental part of implementing these standards was ensuring that language and terminology were adjusted and appropriate to the local culture, which was a way of showing respect and understanding of local context.

In summary, place-based education theory and other related terms and approaches, such as critical pedagogy of place and place-based consciousness, offer an approach to education that could make a positive difference for indigenous students in science education. The following section outlines how place-based education offers a form of transformative praxis or a pathway to what the principles derived from the literature chapter could look like in practice for Māori or other indigenous community-based science education programmes.

3.3 Place-based Education and Indigenous Science Education

This section will be divided into six parts with links made to each proposed principle of an indigenous community-based science programme. Each part will first identify a key issue for Māori science education in New Zealand, introduced with personal anecdotes about my past experiences in education and explained further with links to literature. The issues are further addressed and supported by examples of place-based theory in practice. The highlighting of key issues in a focus research area through personal anecdotes is an example of an autoethnographic tool, where the author's narratives are used to illicit further questions or possible solutions (Cunningham & Jones, 2005). This thesis includes elements of autoethnography (Chang, 2008), which will be explained further in Chapter Four (Section 4.1.3).

Links to the Aotearoa New Zealand science curriculum aims will also be described to highlight the context of this research. The New Zealand science curriculum consists of both English and Māori medium documents. Examples of Māori and science concepts are presented as possible examples of 'common ground' pedagogy. Common ground is a term used by some culturally responsive science curriculum advocates to define the relationship or intersection between indigenous knowledge and science knowledge (Aikenhead & Michell, 2011; Stephens, 2000). Stephens (2000) purports when thoughtful consideration is made of possible connections between indigenous and science knowledge systems examples of common ground can be revealed. These examples could be in the form of principles, values, skills, processes and content knowledge. The main purpose of identifying examples of common ground is for educators with knowledge of either knowledge system to access the other. The examples of common ground pedagogy, underpinned by Māori and science concepts, provide illustrations as to the applicability of the principles for engaging Māori students in science education to support the diverse range of science educators in Aotearoa New Zealand.

3.3.1 Partnerships and Power-sharing

> My practical experience of issues involved with the first principle identified in the literature review of this research, of power-sharing and partnership, was through my role as a Pūtaiao or science curriculum advisor for Māori medium classroom teachers at a college of education. I was asked to be part of an advisory group for a government-funded environmental education contract who were required to deliver teacher professional development services for Māori medium teachers. The contract had already been supporting English medium teachers for at least two years. It was my first experience of the Māori medium setting as being an afterthought or a tick-the-box requirement, as opposed to the priority treatment already given and operating for English medium classrooms. I saw Māori as minor partners with limited control and resources to provide a Māori-directed professional development programme. I was beginning to learn about the issues involved in the development of Māori science education and curriculum development.

My personal anecdote highlights the impact on Māori of their limited input to curriculum and pedagogical decisions. A Māori science curriculum for Māori medium classrooms and schools was first produced as part of the national curriculum *Te Anga Mātauranga* in the form of the Pūtaiao (science curriculum) document (Ministry of Education, 1996) alongside other curriculum statements for all learning areas. The development of these documents, as well as the professional development and resources created to support their implementation, was funded by the state as part of the state's commitment to Māori medium education (McKinley, 2005).

The main issue with the production of the Pūtaiao document was that it was essentially a translation of the English science curriculum, with minimal inclusion of Māori knowledge content or perspectives (McKinley, 2005). This is an example of Māori language and knowledge being compromised and an issue of tino rangatiratanga or self-determination for Māori science curriculum development. The most recent Māori science curriculum development has been in the form of the Pūtaiao section of *Te Marautanga o Aotearoa* Māori medium curriculum framework (Ministry of Education, 2008). This is the latest science curriculum that Māori medium classrooms are working from and was developed by Māori medium curriculum experts. There are some parallel statements in the overall aims section; however, the purpose and content of each learning area was intended to be developed in isolation from the English medium documents. As a result, the Pūtaiao section of the new curriculum document, which aimed to provide equal acknowledgement of each knowledge system through the Māori language, is only possible to a certain level (McKinley et al., 2004).

In practice, the proposed partnership and power-sharing principle component of indigenous community-based science programmes aims to ensure that there are clear processes in place that reflect the wants and needs of local indigenous communities as well as students, teachers and schools. For Māori communities, this principle represents students, teachers and families, making decisions and choices about curriculum content, pedagogy and delivery (G.H. Smith, 2003). Place-based education programmes and pedagogy also support the importance of shared input by all stakeholders.

In their evaluation of a place-based professional development programme for teachers, Meichtry and Smith (2007) identified regular reflective learning practices, such as journaling and group discussions as a fundamental place-based teaching approach. Reflective learning can allow teachers to not only evaluate their own progress and the benefits of a professional development programme, but can also contribute to identifying benefits and challenges for their students. Although not identified in Meichtry and Smith's study, students could also engage in reflective learning as a means to improve teacher practice or programme implementation.

Place-based theorist Gregory Smith's (2002) suggested the teaching about the local as a vantage point to progressing learning about the regional, national or global culture. Exploring the local culture, history and experiences of the students' families and local communities is seen as valid and is acknowledged as being worthy of inquiry (G.A. Smith, 2002). Sutherland and Swayze (2012) reported in their study about science teacher professional development that teachers found their science programmes were more successful for students when they were given autonomy by school management about what and how they wanted to teach. This is an example of partnership and power sharing as teachers were given autonomy to develop their own programmes and could in turn give their students some autonomy by involving them in decision-making.

G.A. Smith (2002) has also described the ‘real-world problem solving theme’ as a teaching approach that empowered students to lead the direction of investigations with the teacher providing resources and making links to school requirements. In their study on effective teaching strategies for including indigenous knowledge into the science classroom, Kawagley et al. (2010) agreed that it was important for students to direct science investigations in a local setting with the support of both the teacher for science skills and knowledge, and local elders for indigenous perspectives. Similar to G.A. Smith’s (2002) ‘real-world problem solving theme’, Kawagley et al. (2010) promoted a classroom that reflected a local village, where students, teachers and elders worked together on tasks that they deemed were relevant to their daily lives, allowing authentic teaching and learning.

The current New Zealand science curriculum documents (Ministry of Education, 2007, 2008) both have aims that ask for critical student input into wider science-related community issues. *Te Marautanga o Aotearoa* (Ministry of Education, 2008) aims for students to be able to:

> Apply knowledge of science to community decisions and actions, in order to think about iwi and wider issues impacting on the individual, society and the environment. (p. 55)

The *New Zealand Curriculum* (Ministry of Education, 2007) has a similar aim that states:

> By studying science, students: use scientific knowledge and skills to make informed decisions about the communication, application, and implications of science as these relate to their own lives and cultures to the sustainability of the environment. (p. 28)

The concepts of kaitiakitanga and sustainability are examples of topics that reflect the concept of common ground (Aikenhead & Michell, 2011; Stephens, 2000) referred to earlier in this chapter, through which the principle of partnership and power-sharing could be enacted.

An examination of kaitiakitanga and sustainability was evident in a research report that outlined a set of guidelines for groups to consider when working with Māori communities about science topics (Cram, 2002). The guidelines were intended for iwi and science organisations; however, they may be applicable to schools working with iwi. The underlying principle tino rangatiratanga was the focus to allow Māori groups to decide what they wanted to investigate, through their preferred methods, to meet their own outcomes (Marsden, 2003). One key suggestion for science groups included ensuring they had a clear understanding of the concept of kaitiakitanga or guardianship before engaging with Māori. A common practice associated with kaitiakitanga includes rāhui or the placement of restrictive access or use of physical spaces to conserve flora and fauna or out of respect for a loss of life or serious accident (Marsden, 2003). Kaitiakitanga is a term that is becoming synonymous with resolving issues of sustainability and natural resource management (Marsden, 2003) and education for sustainability programmes in New Zealand (Eames, Roberts, Cooper & Hipkins, 2010). The use of Māori language to express a Māori worldview in science contexts is explored in this next section.

3.3.2 Shared Values and Aspirations

> I'm a second language learner of my indigenous language. I became fluent in the Māori language primarily through my study at university. My grandparents were native speakers; however, my parents' generation are also second language learners. I chose to be a Māori medium primary school teacher because of my commitment to young Māori having the opportunity to learn their indigenous language. Making a difference for Māori students in science education was a secondary interest but not my main focus. As a beginning teacher my school supported me with the delivery of the Pūtaiao curriculum document by sending me on a course. Other Māori medium teachers and I learnt and shared Māori worldviews of science at marae-based hui with Māori language experts and Māori educationalists. I loved learning about how the Māori language is so connected to our environment. I loved learning how you could play and be creative with language. I learned how you could support your students' understanding of the world around them with language. I learnt different iwi had different stories and interpretations about our environment.

This account shows how having an understanding of an indigenous language can expose people to new learning experiences, knowledge and perspectives.

Indigenous science education commentators argue that having an understanding of the students' indigenous language supports understanding of local cultural practices and knowledge and contributes to addressing the issue of minimal indigenous content in science classrooms (Aikenhead, 1997; McKinley, 2001). The use of indigenous languages in the science classroom also encourages students and teachers to explore different perspectives due to the varied structures of languages representing different worldviews (Metallic & Seiler, 2009). The acknowledgement of indigenous language and culture in the science classroom supports the sustainability of what Māori perceive as 'taonga tuku iho', literally meaning treasures from our ancestors (Marsden, 2003).

One of the intentions of the Māori medium education movement was to address the underachievement of Māori students; however, students in Māori medium settings are achieving below their peers in English medium classrooms in science (Stewart, 2011). These results could be a consequence of limited teacher knowledge of science content and limited teacher Māori language proficiency and knowledge of Māori science terminology, which is still an area of development (McKinley et al., 2004). Some commentators also suggest that the priority of resourcing and focusing on Māori language growth overrides the critical improvement of science teaching and learning in Māori medium environments (Harlow, 2003). One result of Māori language being the learning focus is that the inclusion of Māori knowledge and discourse are secondary in Māori science education development, while Western science is still the basis of the Māori science curriculum (Stewart, 2011).

The shared values and aspirations principle promotes indigenous knowledge and practices as valid components in their own right. Citizenship education, which was identified by Meichtry and Smith (2007) as an important component of place-based education teacher practice, links best to this proposed principle. In practice, this principle aims to identify any issues and aspirations that students, teachers, schools and the wider community deem important and address these through taking action. Part of the identification of the issues and aspirations would involve the use of a range of communicative tools that would incorporate a range of perspectives and possible solutions. Decisions about what final actions would be implemented would be a collective choice that would meet the needs of the whole community.

These practices are similar to G.A. Smith's (2002) 'induction into community processes' theme or a place-based teaching and learning that involves students in the economic and decision-making processes of their community. The aim of this approach is to acknowledge schools and their students as viable intellectual resources capable of contributing to important community needs and issues (G.A. Smith, 2002). In their study about the inclusion of indigenous and Western knowledge into the science classroom, Lee, Yen and Aikenhead (2012) supported this view, and allowed students to choose which perspective best fitted their science goals. This is an example of indigenous students having the choice of the direction of their science aspirations based on what they value culturally. In their study on successful strategies that incorporate indigenous knowledge into the science classroom, Kawagley et al. (2010) viewed the participation of local elders in science programmes as vital.

Students were able to learn about values, such as respect for the environment and human interdependence with a responsibility to conserve our natural resources, mainly through stories and legends retold by local elders.

Te Marautanga o Aotearoa and the parallel document the *New Zealand Curriculum* support citizenship education through the science curriculum with these aims for students respectively:

> (That students will have) sensitivity to the difficult issues of their world (which) will encourage students to find ways in which these can be overcome. (Ministry of Education, 2008, p. 53)

> (That students) learn how science ideas are communicated and to make links between scientific knowledge and everyday decisions and actions. (Ministry of Education, 2007, p. 28)

The Māori concept that has been chosen as an example of how to address these aims and enact the shared values and aspirations principle is to use of te reo Māori as a valid tool in the reporting of science-related issues, ideas, discoveries and investigations. The communication and dissemination of new findings and new pathways is a common practice when dealing with science-related issues. Aikenhead and Michell (2011) identify the common ground for the dissemination of indigenous and science ideas as acknowledging both:

> Local, oral indigenous language, which is technically sophisticated, precise, and place-based (and) written text, which is technically sophisticated and precise, and which adheres to the vocabulary, syntax, and genre specific to a paradigm. (p. 118)

Māori language is a fundamental component of tikanga Māori or Māori values and protocol (Mead, 2003). Having an understanding of Māori language provides access to whakapapa, waiata (songs) and whaikōrero (formal speeches) which contain local knowledge and protocol (Hemara, 2000). As stated in the previous section, Māori terminology like kaitiakitanga, tapu (sacred), waahi tapu (sacred areas) and rāhui (conservation practices) are common terms in reporting on science issues, especially in the area of natural resources (Marsden, 2003; Mead, 2003). This is an example of the suggested Māori and science concepts above, in practice.

3.3.3 Culturally Responsive Pedagogy

> As a pre-service lecturer I shared a video clip with my students about traditional Māori musical instruments to provide examples of Māori interpretations of our world. One example included how two common Māori legends represented Māori having an understanding of the layers within the Earth's atmosphere and the layers of core within the Earth. The first legend speaks of a Māori deity ascending the heavens to collect baskets containing knowledge. The number of heavens is the same as the number of layers within our atmosphere. The second legend speaks of another deity who explored the many levels of the

underworld, as an attempt to cheat mortality. The number of layers spoken of in the underworld is exactly the same as the number of layers in the core of our Earth. When students were asked about what they thought of these ideas, some saw them as ignorant and naive and others saw them as new ideas to explore and contemplate how other cultures are different from their own.

The students in the anecdote above had diverse perspectives about how they viewed the natural phenomena in the natural world, possibly because of their range of backgrounds, values and beliefs. A common issue in many science classrooms is that diverse cultural perspectives are not recognised by teachers in science (Aikenhead, 1997, 2001, 2011). An inability to recognise diversity by teachers may also mean they may not acknowledge student diversity in their classroom. This may result in poor teacher-student relationships as students disengage when their diverse perspectives and backgrounds are not acknowledged in the science classroom.

The culturally responsive pedagogy principle acknowledges teachers and students as each having roles of both teacher and learner in the science classroom. Ako also recognises both indigenous and science knowledge as equally valid in the science classroom (G.H. Smith, 2003). In practice, ako would involve indigenous student and teacher prior knowledge, backgrounds and perspectives being included in science teaching and learning. The validity of science knowledge found within mātauranga Māori (Māori knowledge) would also be important and valued in science teaching and learning (Stewart, 2011).

Experiential learning, another pedagogy that Meichtry and Smith (2007) promoted as an important place-based education teaching and learning strategy, can be linked to these principles and characteristic also. Powers (2004) reported that when teachers were engaged in “concrete, realistic examples of place-based education in action” (p. 23), their confidence and participation in the professional development programme improved. Experiential learning has potential benefits for students too and is an example of culturally responsive pedagogy as students engage directly with their immediate physical, social and cultural environment, mainly through hands-on activities and working with local experts.

Sutherland and Swayze (2012) identified that how well teachers included local indigenous knowledge in the delivery of their science programme was dependent on how well the teachers knew their students. This is an example of culturally responsive pedagogy and ako as a reciprocal relationship between student and teacher is an important component of engaging with their students’ community. In their study on how indigenous knowledge could be incorporated into the science classroom, Lee et al. (2012) stated that to really know a student would first require the teacher to have an understanding of their indigenous worldview. Lee et al. suggested that a benefit of this approach was that students would engage more easily with science about their immediate environment, and then have the confidence to engage with further locations. Their study, aiming at including a Western and indigenous perception of place and time in the science classroom, also found that indigenous students had increased interest and pride in their culture.

Kawagley et al. (2010) summarised a range of indigenous teaching and learning strategies that were used to share traditional knowledge and skills about natural surroundings and phenomena. The two main strategies included oral strategies, such as story-telling, and observation where local elders modelled skills and practices. These traditional practices are similar to current teaching practices linked to culturally responsive pedagogy that include modelling, guided practice, co-operative learning, peer tutoring and hands-on activities. A key finding from this study was that local indigenous elders viewed it as vital for their children's survival to learn about science from an indigenous and Western perspective. An example of a lesson in this study, which combined both indigenous knowledge and Western science skills, saw the science teacher, parents, elders and students working together to experiment with local caribou hide hair removal.

Experiential learning is best represented in the New Zealand science curriculum through these statements:

> Science knowledge is a product of human culture, and belongs to all cultures. Science is knowledge about the natural world and the place of humanity in that world. It involves testing ideas about sensory experience of the world; it is flexible, fallible knowledge, which is continually reviewed and updated. (Ministry of Education, 2008, p. 53)

> (Students) come to appreciate that while scientific knowledge is durable, it is also constantly re-evaluated in the light of new evidence. They learn how scientists carry out investigations, and they come to see science as a socially valuable knowledge system. (Ministry of Education, 2007, p. 28)

To support students to engage with the science aims above, the Māori concept of pēpeha and the science concept of investigations have been identified as possible topics for teachers to explore. Experiential learning can be linked to investigation processes, such as experimenting, observing, questioning, classifying, predicting, the use of models, and monitoring (Aikenhead & Michell, 2011). Some of these processes are similar to those involved with pēpeha. Pēpeha are tribal proverb or sayings and was created by Māori ancestors as a mechanism to collate, interpret and disseminate tribal knowledge and wisdom (Mead & Grove, 2001). For example, the creation of pēpeha, would have involved individual tribal members or groups observing, questioning, interpreting and monitoring tribal activities and then presenting their new learning or understanding in the form of a new adage. In the context of science education, students and teachers could learn alongside each other as they access tribal-related proverbs, stories and history from local Māori about locations they are interested, as a valuable research tool.

The inclusion of Māori concepts in classroom practice has been a focus of recent Māori student achievement research. The New Zealand-based research and secondary school professional development programme ‘Te Kauhua’ (Tuuta, Bradnam, Hynds, Higgins & Broughton, 2004), which focused on Māori student outcomes, revealed that teacher relationships with students supported improvement in this area. The follow-up project ‘Te Kotahitanga’ (Bishop, Berryman, Cavanagh, Teddy & Clapham, 2006) examined what culturally responsive pedagogy could look like in regard to relationships between teachers and Māori students. This research identified ako in their ‘Te Kotahitanga Effective Teaching Profile’ (Bishop et al., 2006) as part of an approach to promoting effective teaching and learning relationships between teachers and Māori students. Similar to G.H. Smith’s (2003) definition of ako, these projects saw the role of teacher and learner as interchangeable between students and teachers. Both projects also identified that it was important for Māori student learning that teachers make connections with Māori culture (Bishop et al., 2006; Tuuta et al., 2004). There is evidence that these projects have improved teacher practice and Māori student achievement results (Bishop, Berryman, Cavanagh, & Teddy, 2009).

In a traditional Māori setting, ako was a practice that involved intergenerational teaching and learning within whānau strongly based on whakapapa (Hemara, 2000; Metge, 1983; Pere, 1982). Tribal knowledge and protocol were accessed through pedagogy such as waiata and pūrākau (stories) (Hemara, 2000). Pēpeha is a fundamental pedagogy for learning about many aspects of Māori culture including history, protocol, geographical references, values and beliefs through the sharing of tribal proverbs and associated stories (Mead & Grove, 2001). Teachers having knowledge of their students’ backgrounds has previously been mentioned in this research as a contributing factor to the positive engagement of indigenous students, including Māori with science education (Abrams et al., 2013; Aikenhead, 2011; Cowie et al., 2011; Glynn et al., 2010). In his work about informing teachers of possible strategies to engage Māori students, Macfarlane (2004) agrees teachers need to learn about local iwi associated with their school. Macfarlane also states that it is important for teachers to gather information about local Māori through sources such as pēpeha and pūrākau in ways they feel comfortable. This may involve either investigating literature, or conversing and listening to people, or involving themselves in common Māori gathering practices such as wānanga (discussion), hui (meeting) and pōwhiri (formal welcome) at local marae (meeting place) (Macfarlane, 2004). These practices are similar to science investigation processes (Ministry of Education, 2007) and could also be used by teachers in the science classroom setting.

3.3.4 Resourcing

> I became a Māori advisor for an education for sustainability national contract, which delivered teacher professional development around Aotearoa New Zealand. I supported English medium facilitators with their understanding of Māori culture, language, pedagogy and perspectives in regards to the environment. I helped produce English medium resources, workshops and publications with a Māori perspective. I supported science-focused institutions, government departments and local councils with Māori issues in environmental education. I was a young Māori woman without a science degree who

> did not feel I had any authority to propose a Māori worldview of science or Pūtaiao. I did, however, have integrity and a commitment to ensuring Māori had a voice in Māori education.

This anecdote describes a range of dilemmas for some Māori educators who want to see Māori culture accessible for all learners in the current Aotearoa New Zealand education system; however, part of achieving this goal can sometimes compromise access for Māori learners. Limited access to resources is of particular concern at the senior science level in Māori-medium science classrooms, because of teachers' limited capability with specialised science and Māori knowledge, and also fluent in the Māori language (McKinley et al., 2004). Some schools have attempted to offer a solution by rotating or sourcing out fluent Māori-language-speaking teachers with both Māori and science knowledge to Māori medium classrooms (Wood & Lewthwaite 2008).

The resourcing principle proposed for an indigenous community-based science programme advocates accessing resources to ensure sufficient capacity, capability, implementation and monitoring support. In practice, the inclusion of local indigenous elders and other local advisors with knowledge unique and relevant to the culture of a specific community would be a vital component of science education. Local physical resources and environment would also be important, as well as local practices that preserve these areas.

In her evaluation of place-based education programmes, Powers (2004) identified four key areas that strengthened implementation and outcomes. The first was the use of the wider community to provide resources, facilities and funding. Meichtry and Smith (2007) also identified that it was important for teachers to support students to decide what they thought were relevant issues in their immediate environment and access pathways and resources to explore these issues.

In their exploration of the importance of place in culturally relevant science education, Sutherland and Swayze (2012) reported that teachers felt they had more success in the implementation of their programme when they had the autonomy to access whatever resources they needed, including local elders. However, a key challenge was accessing local elders who had both an understanding of cultural and scientific knowledge. Lee et al. (2012) reported that many indigenous communities' repositories of local indigenous knowledge about, and skills in, the natural environment risk being lost if local knowledge is not taught to, or engaged with, by local students. Place-based education theorist Gregory Smith (p.590, 2002) described a teaching approach called 'internships and entrepreneurial opportunities' that promotes the community where students have grown up as a viable location for their vocational future. This approach encourages students to see that they do not need to leave home to find themselves, make a contribution and establish a 'place' for themselves in the world (G.A. Smith, 2002).

The *New Zealand Curriculum* (Ministry of Education, 2007) advocates resourcing in the science curriculum from a sustainability perspective in that:

> Students also learn that Earth provides all the resources required to sustain life except energy from the Sun, and that, as humans, we act as guardians of these finite resources… Students can then confront the issues facing our planet and make informed decisions about the protection and wise use of Earth’s resources. (p. 28)

Te Marautanga o Aotearoa (Ministry of Education, 2008) aim is similar:

> Access to the highest professional levels in the world of science is an imperative, as is retaining respect for the natural environment and all its inhabitants. (p. 53)

Marae are central locations of cultural, historical, spiritual, political and sometimes economic resources for many Māori communities, described by Mead (2003) as the pivotal location of Māori ceremony and protocol. Aikenhead and Michell (2011) identified the common ground between indigenous ways of engaging with nature and science was the use of technological tools and processes to understand the world around us. The marae has previously been known as a pā or fortified stockades and is traditionally a tribe-established area with a set of common buildings as well as other spaces, such as cemeteries and churches, used for tribal gatherings and hosting visitors (Mead, 2003). Every marae is physically an example of a unique technological tool and tangible representation of how diverse Māori tribes interpret and understand the world around them. Each marae also has unique processes and protocols operating. Many Māori tribes register their marae as places for common use for residents of, and visitors to, Aotearoa New Zealand (Mead, 2003) and are also offered as spaces for teaching, learning and debating, and rectifying education-related issues (Berryman & Bateman, 2008; Macfarlane, 2004, 2007). Marae could be a rich resource to access information about the previous concepts described including kaitiakitanga, te reo Māori and pēpeha as well as other Māori concepts, knowledge and pedagogy applicable to science programmes and classrooms.

3.3.5 Collaboration

> The first time I was introduced to the idea that science could be a cultural body of knowledge was as a postgraduate student studying papers about indigenous praxis in education. It was during my study that I was exposed to questions like Who defines what knowledge is?, Who decides what is taught at school?, Who defines what scientific knowledge is?, Do different cultures have different perspectives of what science is?, What do different cultures want to achieve with their understanding of science? My postgraduate study allowed me the freedom and confidence to explore these questions with my pre-service and in-service teachers. It helped me understand the Māori medium teachers who struggled with implementing pedagogy that had 'Western' labels and who wanted to use pedagogy embedded in Māori perspectives. It helped me understand my pre-service teachers with science degrees who saw science as a pure and neutral body of knowledge that had no links to Māori bodies of knowledge.

This anecdote identifies questions that many commentators have explored and continue to seek answers to in regards to cultural input, in particular indigenous community input into science education programmes, specifically the curriculum (Aikenhead, 2011; Cobern & Loving, 2001; Costa, 1995; Kidman et al., 2011; Kawagley et al., 2010; McKinley, 2001). As stated previously, many Māori tribes in New Zealand have partnership agreements with the Ministry of Education to improve Māori student outcomes (Ministry of Education, 2012) and the key focus for the latest Māori education strategy is for Māori learners and their families and communities to work with others in achieving their educational goals (Ministry of Education, 2013). There is also evidence of iwi and Māori teachers working with science organisations (Cram, 2002; Ramstad et al., 2009; Royal Society of New Zealand, 2013); however, there is limited evidence of iwi, schools and science institutions working on projects collaboratively (McKinley et al., 2004).

The collaboration principle promotes collaborative processes and systems that implement indigenous and Western science knowledge as complementary components of science education. In practice, this principle would involve students, schools, teachers and Māori communities working together in the delivery of science programmes that included both Western and Māori perspectives. Evaluations of place-based education programmes (Meichtry & Smith, 2007; Powers, 2004) also promoted the importance of teachers, students and the community working together, similar to the whānau (G.H. Smith, 2003) or collaboration principle. Working with the wider community provided teachers and students with a diverse range of perspectives and opportunities to contribute to relevant and real-life issues (Powers, 2004).

In their review of informal science education in indigenous settings, Sutherland and Swayze (2012) explored the importance of place in culturally relevant science education, using Gruenewald's (2003a) critical pedagogy of place philosophy. Their key findings focused on the experiences of science teachers working with local indigenous communities. Teachers had varied knowledge of the local community and in some cases worked with students to access local knowledge (Sutherland & Swayze, 2012), which reflects the collaboration principle promoted by this research. There have been several studies in the native Alaskan community where indigenous teachers have worked alongside local indigenous elders to include local "ways of knowing and doing science" in the science classroom (Kawagley et al., 2010, p. 223).

Collaboration is reflected in the science aims in the *New Zealand Curriculum* (Ministry of Education, 2007) and *Te Marautanga o Aotearoa* (Ministry of Education, 2008) both socially and physically in the following statements respectively:

> (Students) learn how scientists carry out investigations, and then they come to see science as a socially valuable knowledge system.
>
> Students learn that Earth's subsystems… are interdependent and that all are important. They come to appreciate that humans can affect this interdependence in both positive and negative ways. (p. 28)

> Science assists the Māori world to embrace the future. Linking together traditional and modern knowledge enables new knowledge bases to develop and be extended… The student is able to develop (their) own 'baskets' or viewpoints on knowledge, as a foundation for studying those of other cultural origins. (p. 53)

Aikenhead and Michell (2011) identified that both indigenous communities and scientists work in groups and teams to seek advice and make decisions. Collaborative practices are common in science communities where group interactions and final decision-making are important. To support students in achieving the above science aims, the Māori collaborative practice of 'powhiri' or 'formal welcome' is a possible topic for teachers to explore. The fundamental purpose of powhiri is to normalise the relationship between two groups of strangers (visitors and hosts) in a formal setting (Mead, 2003) to allow for positive informal future interaction. McRae and Taiwhati (2011) offer a possible pathway with 'He anga mahi tahi/mahi ngātahi' or collaborative practice framework, developed to support teacher educators with engaging with schools and their Māori communities. This model could also be applicable for science teachers and schools to use and is modelled on components of the pōwhiri or Māori welcoming process that traditionally occurs on marae. The previous section argued that marae were central locations to see Māori concepts in practice and are also offered as collaborative locations for schools and their communities which could also include science education communities (McRae & Taiwhati, 2011). Decision-making about human interdependence with the physical environment could also occur in diverse marae around Aotearoa New Zealand.

3.3.6 Local Context

> As a teacher and an academic I've been lucky enough to travel the country for professional development and research projects. I've been immersed in the culture, language and history of many different iwi and their environment. I've also had the opportunity to share the unique environment of Rotorua with other teachers and colleagues. I've seen Māori communities struggling to fill their paepae with kaumatua, yet still so welcoming to host you. I've seen educators give back to these communities with koha of resources and shared knowledge. I've talked with Māori educators who worked hard at being the mediator between schools and Māori communities even though both were unsure of the other. I've worked with Māori researchers who negotiate the different expectations of Māori communities and outside agencies. The communities I admired the most were the ones who stated that their tūrangawaewae and a desire for a quality education for their mokopuna were paramount. Curriculum and policy aims were ever-changing and fluid and needed to fit to their wants and needs, not the other way around.

This anecdote supports the view that as well as having a good understanding of the indigenous language and culture associated with a particular location, it is also important to have an understanding of the history and issues to ensure the sustainability of the culture of the community (Alaska Native Knowledge

Network, 1998). In the context of engaging indigenous students in science education, school programmes need to be connected to the local community and planned, developed and implemented alongside indigenous community members (Aikenhead, 2001; Brayboy & Castagno, 2008).

In New Zealand, The Enviroschools Foundation is an example of an organisation that offers a collaborative, location-based education initiative in partnership with Māori communities and organisations (Eames, et al., 2010). Their approach is partly focused on science education outcomes, aimed at supporting young people to contribute to the environmental sustainability of their community with resources and pathways for both English and Māori medium schools. The most recent Māori medium national initiative that had a similar focus and approach was the 'Mātauranga Taiao' (Education for Sustainability) professional development project delivered from 2006 to 2008 (Eames et al., 2010). The initiative involved teachers visiting areas around New Zealand gathering ideas about Māori content and pedagogical approaches to education for sustainability as a means of working collaboratively to address sustainability issues in their community. These approaches are two examples of how the inclusion of local context is an important component of addressing indigenous community needs with links to science education.

The local context principle in practice would see aspects of local indigenous culture and history identified by a school and their local indigenous community included in their science programme. In their evaluation of place-based teacher professional development, Meichtry and Smith (2007) identified the:

> Use of the environment as an integrating context across disciplines [as a goal that] addressed… a systems approach to education, [highlighting] the interdependence between human and ecological systems, and [advocating] the importance of where one lives. (p. 16)

This approach links to the proposed local context principle of an indigenous community-based science programme. In practice, teachers would include the local environment and settings as the source to explore local issues students are interested in.

In his review of place-based educational initiatives, G.A. Smith (2002) identified a set of themes to guide teaching and learning in this area. His theme 'nature studies' promotes school investigations that are based on local natural phenomena. Another theme, 'real-world problem solving', involves students in the identification of school or community issues they would like to investigate and address (G.A. Smith, 2002) and could support the student who has an interest in engaging with issues affecting their immediate environment. Lee et al. (2012), in their study about the inclusion of indigenous phenomena in the science classroom, found that indigenous student knowledge about local culture was limited if the students were not situated in their cultural setting. Kawagley et al. (2010) acknowledged that if indigenous knowledge and practices in relation to the natural world are to be preserved, then indigenous students need to be learning about them in authentic settings.

The use of the environment is reflected in the current New Zealand curriculum documents (Ministry of Education, 2007, 2008) in the Ō Mataora (Natural World) strand of the Pūtaiao section of *Te Marautanga o Aotearoa* and the Living World strand of the Science learning area of the *New Zealand Curriculum* in the following statements respectively:

> This strand is metaphorically associated with the majority of the traditional familial deities, which collectively represent a Māori system of organizing and understanding the natural world and the relationships between all living things. It reminds us to respect the mauri (life force) of all things discovered, consumed, or used by humans. (p. 54)
>
> The Living World strand is about living things and how they interact with each other and the environment. Students develop an understanding of the diversity of life and life processes, of where and how life has evolved, of evolution as the link between life processes and ecology, and the impact of humans on all forms of life. (p. 28)

Tūrangawaewae is a Māori concept that describes a person's strong connection or affinity to a physical location (Mead, 2003). Māori oral practices, such as whaikōrero, pēpeha and pōwhiri mentioned earlier in this section, often include the sharing of whakapapa with strong connections to geography (Ministry of Education, 1992). These practices describe the holistic connection that many Māori have with the physical environment (Carter, 2005). Narratives that connect land to people are a common pedagogy for indigenous people that provide a source of knowledge and identity (Whitt et al., 2003). Many Māori view themselves as being intimately connected with the physical environment and have strong kinship ties to their geographical boundaries. This is supported by Carter (2005) who argues that every part of the physical and spiritual world has a whakapapa and is interconnected. Pēpeha describes the relationship many Māori have with their physical environment or their 'tūrangawaewae' and is a way of sharing knowledge about important locations to maintain and sustain the important reciprocal relationship between environments and people (Carter, 2005).

Table 3.2 in the following section, provides a summary of the components of a proposed framework for a Māori community-based science education programme. This framework is based on the theoretical set of principles explored in this section that are proposed as underlying successful indigenous community-based science programmes. The theory is contextualised for Māori with links made to Kaupapa Māori theory. Place-based education theory is used as the basis of examples of teacher practice. Examples of Māori and science concepts are also given as suggested topics or strategies to support a diverse range of teachers to engage Māori students in science education. The next section begins with a table which aims to synthesise the theoretical principles, characteristics, concepts and topics discussed thus far.

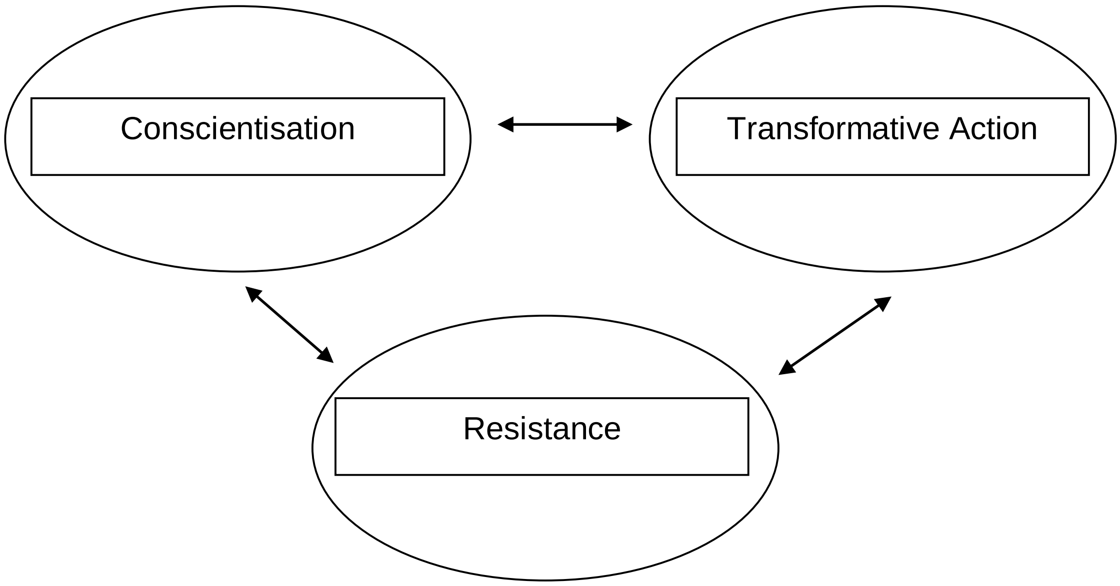
3.4 Māori Community-based Science Education Programmes

Table 3.2 Proposed Māori community-based science programme framework

EXAMPLES OF MĀORI CONCEPTS (As stated in Section 3.3)	**PRINCIPLES IDENTIFIED IN LITERATURE REVIEW (SECTION 2.4)** ***Smith, G.H (2003)** **Stewart, G. (2011)* *PBE pedagogy (Section 3.3)	***EXAMPLES OF SCIENCE CONCEPTS*** (As stated in Section 3.3)
Kaitiakitanga	**PARTNERSHIPS & POWER-SHARING** (See links in Section 3.3.1) **Tino rangatiratanga** *Critical science* Reflective learning	*Sustainability*
Te Reo Māori	**SHARED VALUES & ASPIRATIONS** (See links in Section 3.3.2) **Taonga tuku iho** *Māori worldview* Citizenship education	*Dissemination*
Pēpeha	**CULTURALLY RESPONSIVE PEDAGOGY** (See links in Section 3.3.3) **Ako** *Validity of science & Māori knowledge* Experiential learning	*Investigations*
Marae	**RESOURCING** (See links in Section 3.3.4) **Kia piki ake i ngā raruraru o te kāinga** *Political legitimacy* Pathways & resourcing	*Process model*
Pōwhiri	**COLLABORATION** (See links in Section 3.3.5) **Whānau** *Cultural interdependence* School community partners	*Collaborative practices*
Tūrangawaewae	**LOCAL CONTEXT** (See links in Section 3.3.6) **Kaupapa** *Curriculum* Use of the environment	*Interdependence*

This proposed approach to Kaupapa Māori science education is an example of transformative praxis for Māori (G.H. Smith, 2003) in that the purpose is to transform historically hegemonic science education to support the positive engagement of Māori students in science education. G.H. Smith argued that his six principles that represent his interpretation of Kaupapa Māori theory are important components in the transformation of critical issues for Māori, and states they could be applicable for other indigenous communities with similar historical, social and political backgrounds. G.H. Smith's (2003) view of transformative praxis is shown in Figure 3.1.

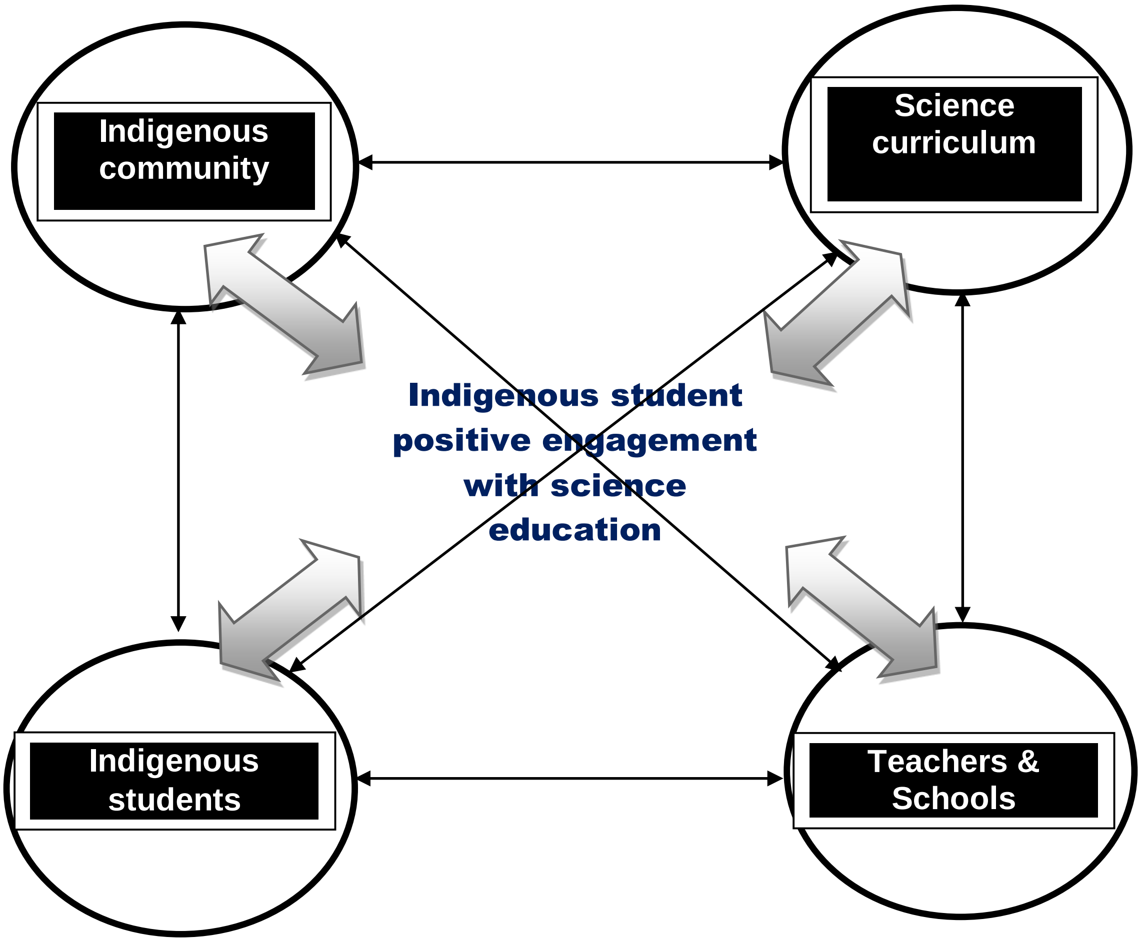
Figure 3.1: A Māori view of transformative praxis (G.H. Smith, p. 13, 2003)



G.H. Smith (2003) begins with the conscientisation component where an area of oppression is identified, followed by the resistance component where possible strategies to counter whatever oppression are explored, culminating in the implementation of possible transformative pathways. G.H. Smith (2003) displays his critical interpretation of transformative praxis as a cyclic process (Fig.3.1), proposing that each part is equally important, can occur simultaneously, and where Māori groups and individuals and other parties concerned can be involved at any stage either proactively or unconsciously.

In the context of the current research, the conscientisation component of Graham Smith's (2003) cyclic interpretation of transformative praxis is represented by the issue of the low achievement of Māori students and other indigenous students in science education. The resistance component includes the tensions in the development of transformative initiatives such as the proposed principles of an indigenous community-based science education. The transformative action component (G.H. Smith, 2003) is represented by the implementation of an indigenous community-based science education. Students, teachers and schools, science curriculum and indigenous communities would all be involved at any part at anytime of the transformative praxis process. Collective equitable proactive involvement by all parties is a fundamental element of the example of transformative praxis proposed by this research. This research uses G.H. Smith's (2003) figure as a guide to display how this thesis proposes what an indigenous community-based science programme could look like, and how it is an example of transformative praxis (Figure 3.2).

Figure 3.2 Proposed indigenous community-based science programme



KEY

Proposed principles in practice

Working relationships including tensions and challenges

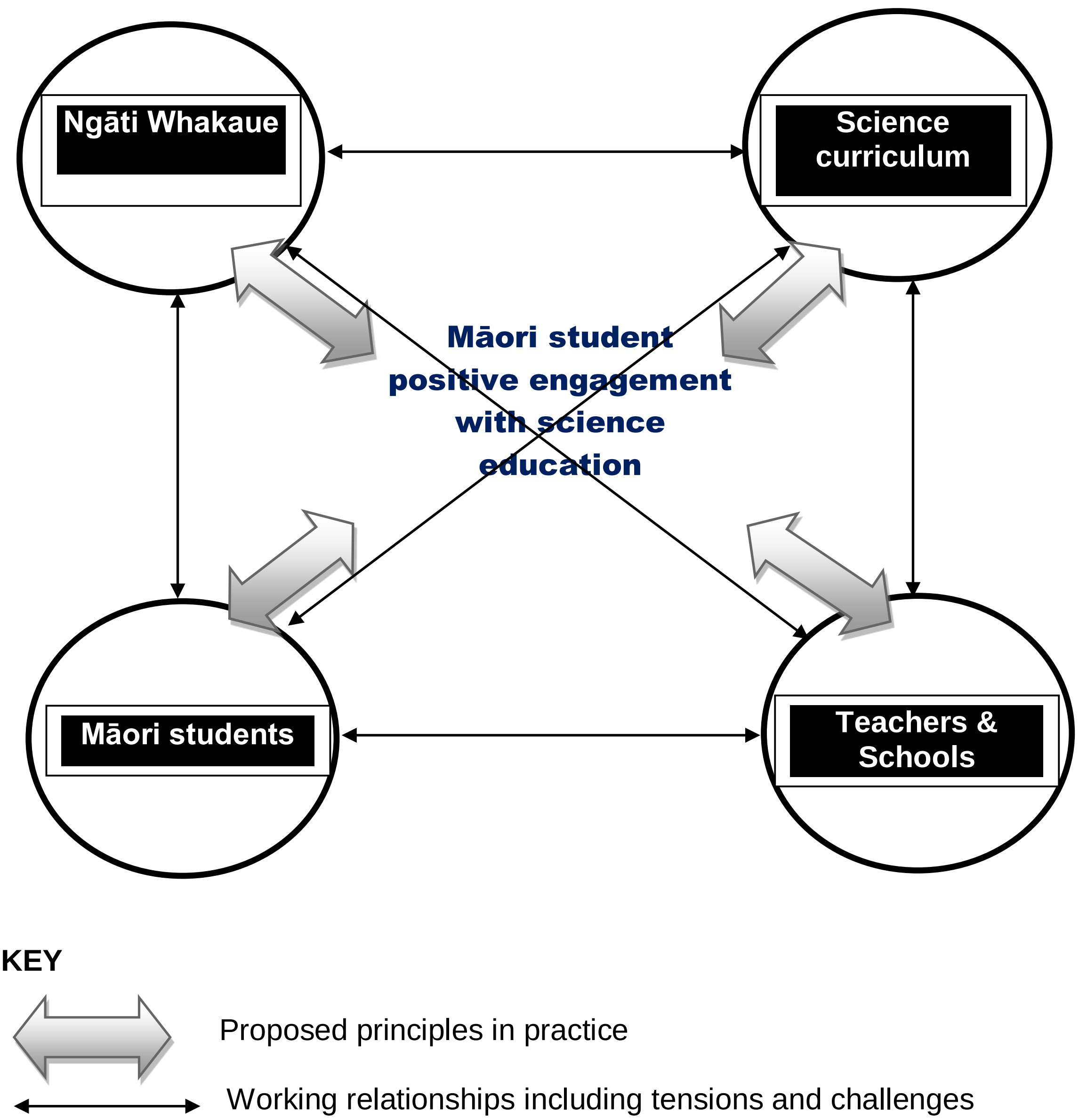
The indigenous students' component represents indigenous students as active and valued contributors to an indigenous community-based science programme to ensure their positive engagement with science education. The indigenous community component could represent any indigenous community, and all aspects of that community such as their history, culture, knowledge systems and resources. The teachers and schools part represents all types of school settings, their students, teachers, families and wider community. The science curriculum component represents the science curriculum and associated organisations such as government agencies, and vocational and tertiary organisations. Each component would have their own theoretical foundations, aims, expectations and resulting preferred practices.

The thick grey arrows represent the implementation of the proposed principles of an indigenous community-based science programme being put into practice by each group. The thin black arrow represents a working relationship and possible tensions and challenges that each component could potentially have with each other component. Individual members or groups within each component could also be involved in any of the other components, for example a teacher of a school may also be a member of an indigenous community. Another example is a principal at a school may be a contributor to national science curriculum development. Also, each component could potentially be involved in each stage of G.H. Smith's (2003) cyclic interpretation of transformative praxis.

3.5 Link to Research Context

The context of this study is Ngāti Whakaue, an indigenous community interested in the provision of science education programmes that will engage their Māori students and in turn impact positively on the wider community. The overall aim is to identify whether the proposed approach to an indigenous community-based science programme is applicable to the Ngāti Whakaue context and what this may look like. The main exploratory question for this research is: “How do schools include Ngati Whakaue in science education?” Figure 3.3 represents what this approach could look like if implemented in Ngāti Whakaue.

Figure 3.3 Proposed approach to Ngāti Whakaue science education



The purpose of this research is to identify issues, benefits and challenges for schools, teachers, students and local Māori elders that occur in providing science education for Māori students in the Ngāti Whakaue community. Another aim is for this contextual exploration of the delivery of science education in one indigenous community to be an example for schools and other indigenous communities to consider as an approach to positively engage their indigenous students.

3.6 Summary

In summary, this research argues that schools and communities have the opportunity to contribute to the positive engagement of Māori students in science education through indigenous community-based science programmes. This chapter described the theoretical framework for this study based on principles identified in the literature review that underpin successful indigenous community-based science education programmes, Kaupapa Māori theory (G.H. Smith, 2003) and Kaupapa Māori science education (Stewart, 2011). The purpose of this chapter was to explain how these connections provide the foundations of what an approach to Kaupapa Māori science education could look like. The argument was supported by identifying common issues for indigenous science education through the sharing of a personal anecdote. Links to what each issue looks like in a Māori context were also presented, followed by a brief summary of how the proposed principles and characteristics in practice could address each issue. Examples of Māori and science concepts were also identified to further explore what Kaupapa Māori science education may involve. Place-based education theory was argued as a possible contributor to the development and implementation of indigenous community-based science programmes and Kaupapa Māori science education. The following chapter will provide an explanation of how these theories will be examined in the context of Ngāti Whakaue.

CHAPTER FOUR – METHODOLOGY

4.0 Introduction

The purpose of this study is to use the principles of an indigenous community-based science education programme developed in Chapters Two and Three, to examine the provision of science education for students in one Māori community. The overarching research question was: “How do schools include Ngāti Whakaue in science education?” To investigate this question, the use of intrinsic case study (Johnson & Christensen, 2008) and autoethnography (Chang, 2008) with methodological practices linked strongly to Kaupapa Māori theory (Bishop, 1996, 2006; Pihama, Cram, & Walker, 2002; G.H. Smith, 2003; L.T. Smith, 1999; Walker, Eketone, & Gibbs, 2006) was adopted. The chapter begins with a justification of why a qualitative methodological approach was chosen for the research design. Second, a set of Kaupapa Māori theory principles are linked to the research approach. Next, the selection of participants is explained, followed by a description of data collection tools and processes. The data analysis and coding processes are then outlined and the chapter concludes with a discussion of the reliability and validity of the research and an explanation of ethical procedures.

4.1 Research Design

Qualitative and quantitative data-gathering methods are common approaches in educational research. Each have their benefits and challenges, depending on the purpose of the research. Quantitative research begins with a hypothesis and gathers evidence, usually in the form of numerical data, to prove or disprove a theory (Mutch, 2005). Conversely, qualitative research does not aim to prove or disprove a theory; however, the purpose is to enhance understanding of particular phenomena. Descriptive unique accounts are gathered from participants, usually in the form of transcribed recorded discussions, where theory or key ideas could arise out of the data (Mutch, 2005). The qualitative research paradigm was therefore selected for this study as the key aim was to understand the meanings or perspectives participants had constructed (Creswell, 2005). More specifically, the aim was to identify participants' perceptions about science education in relation to Ngāti Whakaue.

4.1.1 The Qualitative Paradigm

Qualitative research is interpretive and naturalistic (Denzin & Lincoln, 2005), and it seeks to understand phenomena in their unique contexts and through the interactions that take place in that setting (Merriam, 1998). This study seeks to explore how the phenomenon of science education is implemented and engaged with in one Māori community. Interpretation is integral to qualitative research and can involve, first, the researcher's explanation of why something is taking place and, second, what the experience holds for those who are being studied (Stake, 1995). This study has identified an approach to science education that could improve the engagement of indigenous students, especially Māori. It is important to explore the current implementation and delivery of science programmes within the chosen setting. Participants' everyday experiences and prior understandings are the subject matter of qualitative studies (Scott & Usher, 1999). The qualitative practices of intrinsic case study (Johnson & Christensen, 2008) and autoethnography (Chang, 2008) have been chosen respectively for this research design, first because the study is focused on one particular community and outcomes relevant to them, and second because the community includes one of the researchers' cultural affiliations.

4.1.2 Case Study Method

Aspects of case study method were selected for this research to provide a rich and in-depth understanding and analysis based on one specific community (Mutch, 2005). Qualitative research design describes a case as a 'bounded system' and so the aim of a case study is to tell a story about the 'system' made up of interrelated parts (Johnson & Christensen, 2008). Identifying the boundaries of the system is also an important part of a case study so that there is clarity about what is being explored and what is not (Johnson & Christensen, 2008).

A key aim of educational case study research is to examine educational environments with the intention of making a difference through improving practice (Merriam, 1998). An objective of this research was to offer recommendations to improve the delivery of science programmes for Māori students. Specifically, this research uses aspects of an intrinsic case study design (Johnson & Christensen, 2008) as the focus was to explore how science programmes in Ngāti Whakaue contributed or could contribute to the positive engagement of Māori students in science education. The goal of this type of case study is to understand the chosen setting, its components and all its processes as a holistic entity (Johnson & Christensen, 2008). The overall chosen setting for this research is Ngāti Whakaue and its components include Māori students, science teachers, a range of secondary schools and local Māori elders. An advantage of this in-depth exploration is that the researcher has only one focus. Intrinsic case study method is commonly used in exploratory research where deeper understanding of a particular little-known topic is the main objective (Johnson & Christensen, 2008). There is minimal research in the area of relationships between science education and Māori communities (McKinley, 2005). Aspects of autoethnography were also utilised in this research as the key setting for this study was one of the researchers' cultural communities, specifically the Māori tribal community of Ngāti Whakaue.

4.1.3 Autoethnography

There exists many different interpretations of autoethnography (Chang, 2008) mainly due to differing outcomes of what researchers want to achieve, and the avoidance of being constrained by a set of definitive methods (Adams & Jones 2008). This aversion to pre-determined guidelines, is due to one of the main purposes of autoethnography being, to explore the tensions between personal experiences of the researcher in relation to broader social, political and cultural issues occurring in our communities (Adams & Jones, 2008). A flexible and open approach to research is preferred, to allow intimate, personal and interactive inquiry between the researcher, the chosen issue, participants and the research setting (Ellis & Bochner, 2000).

Autoethnography is essentially a record of a personal narrative where the writing style is usually first person and maybe in the form of a poem, short story or a conversation between the author and reader (Cunningham & Jones, 2005). When presenting autoethnography, it is important that a clear research-focused objective or goal and the parameters of personal interpretations of research activities are shared (Cunningham & Jones, 2005). A key aim of autoethnography is to illicit further exploration of identified issues, and pose new questions and possible solutions from a personal voice not typically heard (Chang, 2008).

Autoethnography was introduced in the theory chapter of this thesis (Section 3.3). Key issues in Māori science education in New Zealand were introduced through the researcher's personal anecdotes about past experiences teaching and learning in science education. The issues highlighted in these experiences were explained further with links to how the principles of an indigenous community-based science programme, identified in the literature review of this thesis (Section 2.4), could address them. The issues were further addressed and supported by examples of place-based theory in practice (Section 3.3).

This research can be seen, in part as autoethnography, as the researcher is a member of the cultural setting, specifically the Māori community of Ngāti Whakaue, and intimately involved in the chosen issue of Māori science education as well as associated social, political and cultural concerns. A key characteristic of autoethnography is that the researcher is a member of the community they are researching (Ellis & Bochner, 2000). Tomaselli, Dyll & Francis (2008, p.351) state that these 'insider' and 'outsider' roles of an autoethnographic researcher is often complicated due to the intimacy of relationships. Possible complications can be managed, if it is clearly communicated, that the researcher is committed to making a positive contribution to their community and that their community's stories will be shared accurately (Tomaselli et al., 2008). The researcher has a long-term commitment to the identified issue. First, as a steadfast Ngāti Whakaue member focused on contributing to their tribe; second as a staunch advocate for the improvement of Māori students positive engagement in science; and finally as a practioner in the field of Māori science education.

Autoethnography aligns with the requirements of Kaupapa Māori research which is the central methodology of this research, in that it is a critical and reflexive inquiry into one particular culture (Adams & Jones, 2008). In particular, like Kaupapa Māori research, autoethnography advocates for indigenous people having a participatory role in research, as stated by Fine et al. (2003):

> [Autoethnography] recognises not only the knowledge accumulated in indigenous communities but also that indigenous values, beliefs and behaviours must be incorporated into the praxis of participatory research. (p.176)

The main methodological approach for this thesis is based on Kaupapa Māori theory through the application of a set of principles hypothesised by G.H. Smith (2003). These principles have been described in the theoretical framework chapter of this thesis as a pragmatic and philosophical guide. Kaupapa Māori theory is based on Māori philosophical and epistemological perspectives and supports research practices aimed at producing new knowledge for Māori outcomes (Cooper, 2012). Scott and Usher (1999) state that having a sound philosophical and epistemological view is fundamental for qualitative research processes, which include case study and autoethnographic approaches.

4.2 Kaupapa Māori Research

In defining Kaupapa Māori research, its inception is commonly seen as an emancipatory approach borne from past experiences of oppression and exploitation of Māori by the dominant Pākehā (non-Māori) structures and processes (Pihama et al., 2002; L.T. Smith, 1999; Walker et al., 2006). A common purpose is research that involves Māori, in order to make a difference for Māori; it should be conducted by Māori, using Māori-identified practices (Bishop, 1996; G.H. Smith 2003; L.T. Smith, 1999). An increasing number of Māori-focused research projects are using Kaupapa Māori principles as the basis of their methodological principles in a range of areas including Māori language revitalisation (Pihama et al., 2002), health (Walker et al., 2006) and education (Taiwhati, Toia, Te Maro, McRae & McKenzie, 2010; Tuuta et al., 2004). There are also recent examples of specifically focused education research projects based on Kaupapa Māori theory practices (McRae, 2012; McRae et al., 2010). This research is a critical analysis of how one Māori community engages with a critical issue in Māori education with the intention of providing solutions for Māori. It is also an example of transformation or addressing an issue through analysis and action, based on Kaupapa Māori theory principles (G.H. Smith, 2003). The methods used to conduct this research and how they relate to Kaupapa Māori research principles are outlined below.

4.2.1 Tino rangatiratanga

The philosophical, epistemological and interpretive nature of qualitative research is reflected in the tino rangatiratanga or the self-determination principle, which aims to explore issues related to sovereignty, independence and autonomy (G.H. Smith, 2003). The key outcome of this principle is for Māori to have meaningful control over their own life and cultural wellbeing (Bishop, 1996). However, due to a colonial history, Māori are not experiencing this control in many areas, including education (Pihama et al., 2002). All aspects of the methodology in this study are underpinned by this principle, which aligns with the overarching aim of Kaupapa Māori research (Bishop, 2003; Walker et al., 2006). These include the choice of the research setting, the background of the researcher, the overall aim of the research, the participants, the research questions and data collection tools, the data analysis, and possible findings and recommendations.

The choice of setting for this study links to the autonomy aspect of the tino rangtiratanga principle, which advocates outcomes for Māori by Māori (G.H. Smith, 2003). This research was focused on exploring the perceptions of Māori students in science education and was conducted in a Māori community, by a Māori researcher, with predominantly Māori participants. Participants were chosen to represent groups from the Ngāti Whakaue community who could provide insights about the relationship between Māori and science education.

The explorative nature of the study and the research question align with the self-determination aspect of tino rangatiratanga (Walker et al., 2006). All interview questions were open-ended and asked participants to provide examples of personal experiences, ideas, and opinions. Participants shared their perceptions of place, Māori culture, science in everyday life, science curriculum content, pedagogy, and delivery in relation to Ngāti Whakaue.

The choice to collect data through focus group interviews was also an example of tino rangatiratanga as it promoted independence, as participants could decide for themselves how they would like to respond to each question (Bishop, 1996). Participants could share as much or as little as they wanted and check their responses in their interview transcripts. Finally, the findings and recommendations of this research are intended to contribute to the Ngāti Whakaue community in whatever way this community decides for themselves (Bishop, 2003).

4.2.2 Taonga tuku iho

Taonga tuku iho literally means treasures passed down through genealogy (Bishop, 2003) and G.H. Smith (2003) interprets this Māori concept as a principle that advocates cultural aspirations and asserts that being Māori is both valid and legitimate. This principle also validates the inclusion of Māori language, culture and knowledge in educational research (Taiwhati et al., 2010). All participants were asked about their perceptions and knowledge of Māori culture and the Ngāti Whakaue setting in relation to science education.

Asking participants questions that explore Māori knowledge and culture provides an opportunity for Māori views about science education to be heard and shared as rich contributions in making a difference for Māori students in science education.

Participants were also given the opportunity to conduct their interview in either English or Māori. One elder and teachers and students from the two Māori medium secondary schools participating conducted their interviews and focus groups in the Māori language. Offering the choice for participants to share their perspectives through the medium of Māori language promotes Māori language as a valid communicative research tool (Pihama et al., 2002; Walker et al., 2006). Another aspect of the importance of sharing knowledge from a Māori worldview can be linked to another of G.H. Smith's (2003) principles, ako.

4.2.3 Ako

Ako is a fundamental concept related to the sharing of knowledge and originates in Māori genealogy protocol (Hemara, 2000; Pere, 1982). In a Kaupapa Māori research context G.H. Smith (2003) defines ako as the reciprocation of teaching and learning between the roles of teacher and student. This principle advocates partnership and collaboration, where participants can share their knowledge and perspectives, and also challenge each other's views (Bishop, 1996). The data collection process and choice of participants is best represented by this concept.

The choice to collect data from students and teachers through focus group interviews provided the participants with an opportunity to share and listen to their peers' knowledge and perspectives. It was also a forum for the participants to challenge each other's views. The individual interviews with Māori elders also provided an example of ako as both interviews were conducted in the presence of other family members from four different generations. The elders gave permission for other family members to be present to provide a support system for the elders during the interview. It was also a learning opportunity for the wider family (Hemara, 2000) as they could listen to their responses and ask their own questions of the elders immediately after the formal interview or at a later time.

4.2.4 Kia piki ake i ngā raruraru o te kāinga

Kia piki ake i ngā raruraru o te kāinga, or the socioeconomic mediation principle, acknowledges actions taken by Māori when any socioeconomic disadvantages or difficulties occur for their community (G.H. Smith, 2003). Kaupapa Māori practices and values work to ensure that a collective responsibility involving the whole community will come to the foreground to ensure the overall wellbeing of the community (Pihama et al., 2002). The socioeconomic position of the Ngāti Whakaue community and the participants was not a focus of this study; however, the improvement of Māori student participation in science education was. This is an issue of difficulty and disadvantage for Māori students, who are an important component of the collective, so affect the overall wellbeing of their Māori community. The choice to involve a range of participants, including Māori students, their teachers and local elders who are all key stakeholders in the community, is an example of this principle in practice.

4.2.5 Whānau

Whānau describes the cultural practices, values, and customs that are organised around collective responsibility (G.H. Smith, 2003). For many Māori, whānau is essential for healthy Māori wellbeing. With a healthy whānau, the likelihood of positive educational experiences and thus achievement has a better chance of being realised (Hemara, 2000). This principle is best represented in the methodology of this research by the way in which participants were accessed. The local elders were contacted through the researcher's whānau connections, which was also the case for connecting with the Māori medium secondary school teachers and students.

The English medium students and teachers were mainly contacted through each school's administration as the researcher had limited connections in those schools. The researcher planned time at the beginning of each focus group session with the students and teachers for each participant to share some background about themselves. This was an opportunity for the researcher to make a personal connection with the participants that aimed to provide an open, trusting and sharing environment to ensure rich group discussion (Walker et al., 2006).

4.2.6 Kaupapa

G.H. Smith's (2003) final principle, kaupapa, or a collective philosophy, aims to ensure that Māori-centred initiatives within education are held together by a collective commitment and vision. It ensures that such initiatives are connected with Māori aspirations for political, social, economic, and cultural wellbeing (Pihama et al., 2002). The overall aim of this research is to explore the relationship between Ngāti Whakaue and science education and how they both contribute to positive engagement of Māori students in science education. This principle is reflected in the methodology of this research through the choice of participants and their responses to the research questions. Māori students, teachers, and local elders are all key stakeholders in the Ngāti Whakaue community and their responses to the research questions were deemed vital to exploring the research aims (Walker et al., 2006). The care and consideration of participants was the one of the key reasons for using Kaupapa Māori theory as part of the methodological practices. This will be described further in the following section.

4.3 Participants

4.3.1 Key Groups

Participants included kaumātua (local elders), Māori students studying senior science, and secondary science teachers all living, teaching and learning in the Ngāti Whakaue setting. The aim of this study was to explore how the phenomena of science education is experienced in one particular location to contribute to the development of an indigenous community-based science programme. Therefore, it was seen as necessary to work with participants based in the Ngāti Whakaue area. Māori students are a central focus of this study, so the exploration of their perceptions of how they viewed their science education experiences was a fundamental contribution. Their science teachers' perceptions of science education were also important as the key deliverers of science programmes. Finally, the perceptions of local indigenous elders were deemed necessary to represent the research setting.

4.3.2 Selection of Participants

There is a considerable amount of research regarding the underachievement of Māori students which contributes to a prevalent deficit view of their abilities (Bishop, 2003; Caygill, 2008; Chamberlain & Caygill, 2012; Crooks & Flockton, 2004; Crooks, Smith, & Flockton, 2008). Conversely, there is an increasing amount of research that focuses on improving Māori student achievement, by asking students what support they think they need (Bishop et al., 2003; 2006; 2007; 2009; Kidman et al., 2011; Macfarlane, 2004) and what they think contributes to Māori student success (McRae et al., 2010; Macfarlane, Webber, Cookson-Cox, & McRae, 2014).

The use of student narratives in Māori education research is a recent methodological approach, primarily focused on secondary school students (Bishop et al., 2003; 2006; 2007; 2009). A key attribute of these positive research projects, has been valuing Māori student voice as a crucial contributor to the improvement in Māori student achievement, specifically Māori secondary school students (McRae et al., 2010; Macfarlane et al., 2014). This research positions student voice as a fundamental asset to identifying what works best for Māori students in science education.

The secondary school setting was also chosen, as the researcher wanted to work with Māori students who were taking senior science subjects to examine their engagement with science education. If the students were participating in science at a secondary school level, then there was a high probability they must have had positive experiences at primary and intermediate levels of schooling, which aligns with the positive paradigm of this research. Focus group questions also allowed students the opportunity to share their primary and intermediate science education experiences.

The choice of only working with secondary school students was not intended to disregard the value of younger Māori perceptions of science education or assume they have not had positive experiences. These are the chosen parameters of this project and its outcomes could still be applicable to primary school and junior secondary school science programmes. This study is not primarily intended to provide recommendations for all Māori secondary school students or secondary school science programmes. However, it offers suggestions for science education programmes, at all levels including English and Māori medium settings. This research understands that complex issues exist in all of these settings, which should be explored within each unique environment. For example, the researcher is highly interested and motivated to explore future projects that consider issues specifically about positive engagement of Māori primary school students in science education, due to the majority of their teaching experience being at this level.

Māori students' secondary school science teachers were chosen as they were the core deliverers of school science programmes. All secondary schools that were operating in Rotorua during the data collection period of this research (July – October 2010), five English medium and two Māori medium, were contacted to participate in the project. This included five English medium and two Māori medium schools. The researcher felt it was necessary to give all secondary schools the opportunity to share their experiences of science education in the Ngāti Whakaue setting.

The researcher was very hopeful that each school would participate for a number of reasons. First, as the schools were based in Rotorua, it would be highly likely that each school would have Ngāti Whakaue affiliated students and teachers. It was hoped that each school would want to support Ngāti Whakaue education because of its location and for their teachers and students to have a voice. Second, each school would have a documented commitment to Ngāti Whakaue education, as the majority of schools received financial support from the tribe. Third, the researcher assumed some schools would participate because of the researcher having either a personal or professional history with particular schools. Subsequently, only one school principal agreed to participate because of the researcher's focus on Ngāti Whakaue. The remaining schools had varied reasons for participating including, supporting the researcher, supporting their Māori students, and supporting themselves in incorporating Māori culture in their science programmes. A total of six out of the seven secondary schools in Rotorua agreed to participate in this research.

Accessing students and teachers was initially arranged through correspondence with senior management members from the secondary schools. Initial communication was mainly with the school principal, and then responsibility was given to either another senior school manager or the head of the science department to arrange appropriate times for the students and teachers to be interviewed. Communication was mainly by email and phone conversations. Actual face-to-face communication was made the day of the interviews in most cases. In two of the schools, face-to-face meetings were held with senior management members days or weeks before the interviews. Meeting with the majority of the teachers and the heads of science departments happened on the day of the interviews.

This research aims to support Māori student engagement with science education; therefore, as stated earlier, it was fundamental for students' voices to be heard. Students were identified by either a senior management staff member of the school or by teachers in the science department; however, their participation was voluntary. All were participating in senior science or pūtaiao subjects. Students did not have to be of Ngāti Whakaue descent as their experiences as Māori learning in the Ngāti Whakaue setting were seen as valuable whether they had affiliations or not. Consequently, the students were of mixed Māori tribal descent and their academic success in senior science ranged from participating to excelling in senior science. The researcher interviewed Māori senior secondary students (Year 11 – 13), from six out of seven Rotorua secondary schools, including four English medium and two wharekura or Māori medium schools. In total, 29 students were interviewed; 14 males, 15 females; 13 Year 11, seven Year 12, nine Year 13; 22 English medium and seven Māori medium students.

The original intention of the study was to interview the school principal or chosen senior management representative from each of the Rotorua secondary schools and wharekura (Māori medium secondary schools) and teachers involved in the senior science teaching and Māori student achievement outcomes at each school. In the end, only senior science teachers in six of the seven secondary school settings were interviewed. Principals or senior management members or teachers specifically involved with Māori student achievement outcomes did not participate in the research as most felt that the science teachers would provide the best responses. Some were also not available to participate at the scheduled interview times. It was not necessary for the principal or teachers to be of Māori or Ngāti Whakaue descent and the most important criterion was that they were teaching and involved in science programmes within the school. In total, 25 teachers were interviewed, including five from wharekura all involved in senior science teaching. A summary of the teacher and student participants identifying the type of school, gender and ethnicity of teachers, and gender and year level of students is shown in Section 4.3.3 in Table 4.1.

The criterion for selecting kaumātua was Ngāti Whakaue affliated elders living in Rotorua for at least 20 years or the equivalent of a generation. Elders did not have to be of Ngāti Whakaue descent and instead could have a strong affiliation with the Ngāti Whakaue people and have spent a long period of time in Rotorua. The researcher interviewed two kaumātua she knew well so that these participants could possibly provide further contacts. One kaumātua was Ngāti Whakaue and the other had married into Ngāti Whakaue. Both had lived most of their lives in Rotorua. The researcher contacted a further three elders suggested by the first two participants, but they were unable to be interviewed due to busy schedules or declined to participate as they felt they had nothing to offer to the study. The reasons given by elders for not wanting to or not being able to participate indicate the following possibilities. Local elders are few but they are still involved in many tribal commitments. They may also have been either given limited opportunities to participate in research or their past experiences have not been positive or acknowledged. More participants may have provided more diverse perspectives. However, the two participants provided diversity as they were from two different generations, had different tribal affiliations, and had spent different periods of time in, and had different experiences and roles within, the Ngāti Whakaue setting.

4.3.3 Participant Description

The school description has been limited to the medium of instruction. Because of the small number of secondary schools in Rotorua, further information could identify each individual school, such as the type of school (single sex or co-educational) or decile rating, which reveals the socioeconomic status of each school. The teacher information has been restricted to sex, Māori or non-Māori, and overall teaching experience. The total number of teachers is not the total number of science teachers at each school. This information would also make the schools identifiable. Further information about teachers' individual experience and subject areas could also reveal their identities. The students' information is limited to overall number of males and females as a breakdown in each school would make the only all-male and all-female schools in Rotorua identifiable as there is only one of each. Tribal affiliations were gathered from participants; however, as the context of the study is Ngāti Whakaue, only this information has been shared. Table 4.1 provides a summary of teacher and student participants.

Table 4.1: Summary of teacher and student participants

School & Type EM-English medium MM-Māori medium	**Teachers n=25** 6 Māori 19 non-Māori	**Students n=29** 14 males 15 females
One – EM	3 male, 2 female **(5)** All non-Māori 5 – 24 years' experience	2 Year 11, 2 Year 12, 2 Year 13 **(6)** Two Ngāti Whakaue
Two – EM	1 male, 4 female **(5)** All non-Māori 1 – 30 years' experience	2 Year 11, 2 Year 12, 2 Year 13 **(6)** Four Ngāti Whakaue
Three – EM	2 male, 1 female **(3)** All non-Māori 5 – 30 years' experience	3 Year 11, 1 Year 12, 2 Year 13 **(6)** Three Ngāti Whakaue
Four – EM	4 male, 3 female **(7)** One Māori (Ngāti Whakaue) 2 – 42 years' experience	1 Year 11, 1 Year 12, 2 Year 13 **(4)** One Ngāti Whakaue
Five – MM	2 female **(2)** Both Māori (1 Ngāti Whakaue) 4 and 20 years' experience	4 Year 11 **(4)** Three Ngāti Whakaue
Six – MM	3 female **(3)** All Māori (1 Ngāti Whakaue) 4 – 20 years' experience	1 Year 11,1 Year 12, 1 Year 13 **(3)** Two Ngāti Whakaue

Pseudonyms were given to each participant in the form of a descriptor that identified whether they were a student (A), teacher (T), which of the six schools they were from (S1 through to S6) or local elder (K). This research is confidential and the purpose of creating the pseudonyms was to protect participants' identities. Students and teachers were not identified individually, as at times it was difficult to differentiate each participant during the primary chosen data-gathering method of focus group discussions. Providing individual descriptors also posed the risk of students and teachers being identifiable as the focus group numbers and total numbers of schools were small. A descriptor from AS1 to AS6 was used to identify a quote from an individual or group of students from each individual school, with the 'A' representing that it was a student quote and the 'S1' through to 'S6' indicating which one of the six schools the student was from. Descriptors for teachers followed a similar pattern, from TS1 through to TS6. There were only two local elders and they were given the descriptions K1 and K2. The data-gathering methods will be explained in detail in the following section.

4.4 Data Collection Tools and Processes

Common data-collecting tools in qualitative research include semi-structured interviews conducted individually or in groups, and participant observations to gather data such as participants' narratives including stories, descriptions, opinions and experiences (Mutch, 2005). Semi-structured interviews gave a balance of flexibility of structure with the researcher providing participants with topics of discussion and some guiding questions (Patton, 2002). Open-ended interviews are similar where the focus is on allowing participants to direct discussions by sharing their thoughts and ideas about the research context (Johnson & Christensen, 2008). These types of interviews are the principal method for gaining an in-depth understanding of a topic, phenomenon or hypothesis through exploring participants' perceptions (Mutch, 2005). The focus of this research was to explore a specific group of participants' perceptions of the phenomena of science education in a specific location. Open-ended interviews and focus group discussions were chosen as the primary data-gathering tools to gather this information.

4.4.1 Interviews

A total of 14 interviews were conducted, including two individual with the local elders and 12 focus group interviews across the six participating schools with teachers and students. The researcher chose to conduct open-ended interviews individually with the local elders to allow them an intimate and respectful environment to share their thoughts and feelings about the research topic (Johnson & Christensen, 2008). The individual interviews with the Ngāti Whakaue-affiliated elders were conducted in the participants' own homes and with other family members present. The interviews were still one-on-one with each of the elders, where only the researcher and the elder's responses were recorded. No input from the other members present was requested during the individual interview or recorded by the researcher. The two elders and family members all shared that they appreciated either the opportunity to share their story in a familiar and comfortable environment with people whom they cared for and trusted, which reflected Kaupapa Māori theory practices involving whānau (Bishop, 1996).

Focus group discussions were chosen as the principal data collection method for the Māori students and science teachers. This is a popular method for research in school settings as schools are busy places and that may have limited time to offer extra activities such as research projects (Mutch, 2005). Focus group discussions are a time-efficient method for schools and the researcher as data can be collected by a group of individuals in a shorter period of time. These discussions can also generate rich data as participants have the opportunity to share, listen, and debate each other's ideas.

All participating schools were generous in their allocation of time to be a part of this research and in all cases teachers appreciated the opportunity to share their thoughts and ideas which was shown by the quantity and quality of the responses. All groups of teachers were collegial in that they allowed each other to contribute which was also monitored by the researcher by asking each participant to answer each question if they wished to. The students needed some encouragement at times so the researcher ensured each participant was asked the question directly; however, they were also given the choice to respond or not.

4.4.2 Interview Processes

All participants were given a copy of the interview and focus group questions along with their consent form at least a week before the scheduled interview or group discussion to allow the participants time to reflect and prepare their ideas if they chose to. There was no expectation that each participant had to respond to each question; however, it was important that each was given the opportunity to respond if they chose. In most cases, the teachers and students had completed the consent forms and made notes for the interviews before the focus group discussions. It was never the intention for the interview question forms to be completed or used as main sources of data. The forms were collected and some teachers and students wanted to finish completing them to a more finished state. However, it was explained before and after the interviews that this was not necessary as the provision of questions was only to help them in their preparation. Overall, the focus group discussions for both teachers and students generated the sharing and challenging of ideas, as intended. The question forms were a useful support tool for all participants to prepare for their discussion, which may have supported their confidence to share, as well as being a guide for the direction of the discussion. Field notes were taken during individual interviews and focus group discussions to describe the data-collection setting and record any background information that the participants shared.

All interviews and focus group discussions were recorded by audiotape and transcribed by the researcher and two transcribers. The interviews were conducted in either English or Māori or sometimes both. All the interviews in

English with one elder and four groups of teachers and students were transcribed. Direct quotes in the Māori language with an English translation have been included in examples of participant responses in the findings. This practice of presenting participant responses in the Māori language is an example of taonga tuku iho, as the Māori language is presented as a valid communicative research tool (Bishop, 1996; Walker et al., 2006). The Kaupapa Māori theory principle of ako (G.H. Smith, 2003) in practice is also an example of a valid communicative research tool, as the fundamental purpose is to share knowledge. The choice to collect data through open-ended interviews and focus group interviews guaranteed the sharing of knowledge.

4.4.3 Choice of Questions

There were seven sets of questions asked of participants in the individual interviews and focus group discussions. These can be found in Appendix One. The first set were background questions; the second focused on exploring participants' perceptions of place; the third were about views of science and school science; the fourth examined views about Māori culture; the fifth about any relationships between Māori culture and science; the sixth about Māori culture and school science; and the final questions pertained to Ngāti Whakaue.

First, participants were asked some background questions. In qualitative research it is essential for the interviewer to establish a rapport with their participants to make it easier for them to share their thoughts and perceptions (Johnson & Christensen, 2008). The aim was to learn about each participant's background through their sharing of what they thought were special and significant places for themselves. The next set of questions explored their perceptions of place in more depth.

Next, participants were asked a set of questions associated with aspects of place-based theory (Barnhardt & Kawagley, 2005; Gruenewald, 2003a, 2003b; G.A. Smith, 2002; Penetito, 2009), which was promoted in Chapter Three as a positive contributor to indigenous science education. Primarily, these questions explored the local context principle outlined in the literature review and theory chapters of this research as a necessary component of an indigenous community-based science programme. This principle advocates the inclusion of local phenomena, community resources, local issues and authentic settings in indigenous science teaching and learning.

The purpose of the next set of questions was to understand the participants' perceptions of, participation in, and enjoyment of science in their daily lives away from the school setting. The questions about science activities aimed to provide clear examples or parameters of what participants perceived science to be. These questions were also asked to explore the principle culturally responsive pedagogy, another important component of the indigenous community-based science programme. This principle promotes the importance of acknowledging and including indigenous students' worldviews and backgrounds in science teaching and learning (Metallic & Seiler, 2009).
School science was explored by asking participants about their favourite aspects of school science, how it was taught and learnt, their science education aspirations, and how local issues were included in their science education.

These questions were asked to gain an understanding of the participants' beliefs, values and philosophies about science and science education. Another purpose was to identify how science teaching and learning occurred for each participant in the school and classroom setting, and their preferred pedagogy and teaching and learning environments. These questions also explored the culturally responsive pedagogy principle that promotes the importance of curriculum content and pedagogy that connects with a student's culture (Bishop & Glynn, 1999) in science education (McKinley, 2005).

The next set of questions aimed to identify participants' views about the wider topic of Māori culture, then the research setting of Rotorua and more specifically Ngāti Whakaue. The shared aspirations and values principle was explored as it advocates the recognition of indigenous knowledge as valid (G.H. Smith, 2003) and as it is an important part of indigenous education (Aikenhead, 2001; Barnhardt & Kawagley, 2004). This set of questions was also formulated in preparation for the questions about the relationship between Māori culture and science.

The questions about Māori culture and previously about science prefaced discussions concerning participants' perceptions about connections, if any, between aspects of Māori culture and the world of science. The collaboration principle, which promotes collaborative processes and systems to ensure the implementation of both indigenous and science bodies of knowledge in science education programmes was explored through this set of questions.

The next set of questions was asked to explore the participants' views about the relationship between school science and Māori culture. The main purpose of these questions was to identify whether and how Māori culture was being included in the teaching of school science. The inclusion of aspects of Māori culture in the science classroom could indicate that the teacher views Māori and science knowledge as an important component of science education. It could also indicate that the teacher also valued input from their Māori students and community in their science programme. The partnership and power-sharing principle promotes teaching strategies and teacher attitudes and beliefs that allow partnership and power-sharing with Māori students and their communities (Bishop & Glynn, 1999).

Finally, questions about Ngāti Whakaue in relation to teaching science were asked. The first aim of these questions was to identify whether or not Ngāti Whakaue was included in the science classroom. It has already been established that cross-cultural science teaching units support positive outcomes for indigenous students in science (Aikenhead, 2001). Another aim of these questions was to identify what support the participants would need if Ngāti Whakaue contexts were included in school science programmes. Sufficient funding from a range of sources that provided time for teachers to be released to research, write and create resources was identified as an important component of indigenous community-based science programmes (Aikenhead, 2001; Barnhardt & Kawagley, 2005). These questions also explored the local context principle which, as stated earlier, advocates the inclusion of local phenomena in indigenous science teaching and learning.

4.5 Data Analysis

4.5.1 Kaupapa Māori Theory

This research is interpretive (Denzin & Lincoln, 2005), aimed at describing a Māori perspective about issues in Māori science education, and it was the role of the researcher to make sense of the participants' perspectives. Therefore, Kaupapa Māori theory principles (G.H. Smith, 2003) were used as a guide for different stages of the data analysis process and examples of these principles in practice are given below.

The data were analysed by examining the participants' actual verbatim accounts of their perspectives and views of particular phenomena (Johnson & Christensen, 2008). The analysis is an example of tino rangatiratanga as the findings could provide a valued contribution to Ngāti Whakaue in potentially making a difference for Māori students participating in science education in schools in the Rotorua area.

The researcher viewed the participants' responses as representations of taonga tuku iho (G.H. Smith, 2003) or treasures passed down through genealogy. During the analysis stage of this research, it was the researcher's key focus to ensure the views of the participants were interpreted and reported as the participants had intended. This was ensured through sending each participant the transcript from their interview or focus group discussion to check, as well as the summary of findings established by the researcher.

The process of data analysis is also an example of the ako principle in practice, as interpreting the participants' responses was a learning privilege for the researcher. The practice of ako continued as the researcher gained further understanding of the data by reading the participants' transcripts and field notes several times to identify possible themes and patterns. This is typical of a qualitative analytical approach to analysis and where the coding and classifying of data begins (Scott & Usher, 1999).

4.5.2 Thematic Analysis

A common approach to analysing qualitative data follows three processes of data reduction, data display and conclusion drawing and verification (Scott & Usher, 1999). Data reduction involves simplifying the data to make it more manageable to analyse. Data display is also about making the data more manageable by organising the often large amounts into tables, charts or graphs. Conclusion-drawing and verification involves noting patterns and relationships in the data and checking the validity by referencing theory (Scott & Usher, 1999). All three of these processes were followed in the coding of the data in this research.

More specifically, a thematic analysis approach was used to first reduce and simplify the raw data, which was in the form of text documents transcribed from the interviews and focus group discussions (Mutch, 2005). A thematic approach is appropriate for this research as the purpose is to best represent participants' perceptions, which through this process are achieved by identifying emerging themes from the data. Mutch (2005) describes a thematic analysis process, which was used to guide the data analysis stage of this research. These data analysis stages include: browsing the data; highlighting anything of interest; coding by noting key terms or themes; grouping and labelling emerging themes; developing and categorising key themes; checking for consistency and resonance; selecting examples; and reporting findings.

Furthermore, the data was analysed in two stages using both deductive and inductive analysis (Fereday, 2006). First the data was examined through inductive analysis, where themes were identified through frequency and common patterns, then deductive analysis to determine the prescence of the principles of an indigenous community-based science education programme in the data. Further details of how each stage was conducted in this research are outlined below.

Browsing the data involved each transcript from individual interviews and focus group interviews analysed individually based on the order of the questions asked by the researcher. Participants' responses were paraphrased or summarised to group common responses to each question. Common responses were identified by the repetition of key words, sentences or phrases. The frequency of these responses was recorded in a table under the heading of each set of questions. This was an example of the data reduction and data display processes (Scott & Usher, 1999). For example, the first set of questions asked participants about their place-based connections. The first question of this set was, *"Describe a place that is special and significant to you and why?"* The range of responses were recorded and displayed in a table. For example:

Where is a special and significant place to you?

Rotorua	*1*
Northland	*Opononi, Maungonui*
Australia	
Taupo	
Te Puke	

Why is it special and significant?

Visit family	*1,1,1,1*
Grew up there	*1,1*
Activities	*Waka ama with Hector Busby* *Keep learning about where I'm from* *Learn about future leadership roles*

The individual transcriptions were then grouped into their participant sets of local elders, teachers and students. This was the second stage of analysis, where each participant group's responses were tabulated so that the types of responses to each question and the frequency from the whole participant group could be identified. This again is an example of the data reduction and data display processes (Scott & Usher, 1999). Below is an example of all of the student responses to the question: *"Describe a place that is special and significant to you and why?"*

Where is a special and significant place for you?

Rotorua	*1,1,1,1*
Northland	*Opononi, Maungonui*
Australia	
Taupo	
Te Puke	
Awahou	*My life's out there... my awa... everything's out there.* *Whānau* *Papakāinga*
Manutuke	
Maketu	
Tairua	
Mahia Peninsula	
Te Whaiti	
Te Araroa	
Home	*1,1,1,1,1,1,1*
Anywhere	*1*
Nan's house	*1*
Tauranga	*1*

Island Bay, Wellington	*1*
Rotokawa	*1, Peaceful, beautiful* *1, Waka ama*
Mokoia	*Isolated* *Lots of stories (Te Pakanga o Te Arawa me Ngā Puhi)*
Tarawera	*Lots of stories*
Whakatane	*He waahi pai ki te kauhoe.* *Whānau*

Why is it a special and significant place?

Visit whānau	*1,1,1,1,1,1,1,1,1,1,11,1,1,1,1,1,1*
Grew up there	*1,1,1,*
Activities	*Waka with Hector Busby* *Keep learning* *Take up leadership roles* *Swimming* *Camping* *Waka ama he waahi pai ki te kauhoe.*
Environment	*Warm and nice* *Peaceful, beautiful* *Isolated*
Stories	*Lots of stories (Te Pakanga o Te Arawa me Ngā Puhi)*

Being around whānau	*1, learn more when I'm around them*
Being with friends	*1, feel more comfortable*
My things around me	*1*
Feel safe	*1*
Where I'm from/born	*1,1*
Papakāinga	*1*

Direct quotes that highlighted common responses were also noted in the tables of response frequency organised under each set of questions. A reference to the actual page number of the individual transcript was also made in the analysis tables as a checking mechanism. The tables were used as a guide for when the researcher reviewed the transcripts again to explore the wrap-around discussion associated with common responses identified. This was supported by identifying the first set of broad themes.

The analysis tables and transcripts were then used to identify and code key themes under the headings of the sets of questions, which included background questions; and perceptions of place, science and school science, Māori culture, Māori culture and science, Māori culture and school science, and Ngāti Whakaue. Broad themes were initially identified according to the researcher's analysis, knowledge of the topic, and knowledge of the issues identified by the participants. Themes were identified for each set of responses first in relation to their reponses to the questions, then in relation to the types of responses given.

Patterns were identified for each group first and then these were compared with the other groups. Similarities and contradictions and further questions to be explored in the discussion component of this research were identified at this stage. The patterns were named and explored to see if they could be categorised within and across groups to identify specific themes. Random or minimally represented responses were also noted for further exploration. Intermittent short summary reports were written for each group and shared with peers and supervisors to critique and support theme identification.

The final set of themes was first organised under the proposed principles of an indigenous community-based science programme, which aligned with the questions asked of all the groups of participants. The degree to which each group of participants were reflected in each theme was also noted. Any relationships or contradictions between groups were also summarised.

The transcripts were analysed again with the focus being to check the validity of the identified themes and to possibly discover themes missed. Another focus was to ensure the narratives from the participants were being truly represented by the themes identified.

This re-read of transcripts was also an opportunity to identify pertinent quotes from participants that best represented the themes. These quotations were from individual participants or discussions that the researcher thought exemplified the ideas or discussion points the identified themes were aiming to describe.

As a result of this thematic analysis process (Mutch, 2005), a set of key findings was identified along with further questions for discussion, implications, further issues, possible practical solutions and areas for further research. These key findings were cross-checked again with the original transcripts to ensure validity and reliability, especially examining possible data that disconfirmed key findings. This process will be discussed further in the next section.

4.6 Validity and Reliability

Demonstrating the validity of the researcher's interpretation of the data is integral to qualitative research. An explanation needs to be provided as to why something is taking place, as well as an account of what the experience holds for those who are being studied (Stake, 1995). Kaupapa Māori theory is the main methodological approach for this research, so therefore was the key mechanism to ensure validity and reliability of findings.

The kaupapa or collective philosophy Kaupapa Māori theory principle (G.H. Smith, 2003) is evident in the data analysis process. Participants were chosen to represent the Ngāti Whakaue community, which for some seemed a daunting task to see themselves as possible representative voices of their community (Bishop, 1996). It was the responsibility of the researcher to in turn represent participants' contributions as to how participants intended for them to be shared.

The whānau Kaupapa Māori theory principle (G.H. Smith, 2003) in action is also an example of a data analysis validity tool. This principle describes the cultural practices, values and customs that are organised around whānau and collective responsibility (Pihama et al., 2002). The participants were accessed through the researcher's whānau connections and networks. The researcher had a responsibility to report back accurately and with integrity to the research 'whānau' or the participants. An example of this in practice was that participants were given the opportunity to check their responses in their interview transcripts. The data provided multiple perspectives on how a range of participants interpreted and engaged with the research focus. The provision of varied interpretations and experiences by participants about their understanding of a research focus can increase the credibility of the research findings (Patton, 2002).

Kia piki ake i ngā raruraru o te kāinga, or the socioeconomic mediation principle (G.H. Smith, 2003), is reflected in how the researcher has interpreted the data in relation to the research setting. This research is an intrinsic case study with the Ngāti Whakaue setting being the 'bounded system' (Johnson & Christensen, 2008). A common validity issue involved in qualitative research is the researcher managing their bias in the setting and all of the interrelated parts involved (Scott & Usher, 1999). A qualitative researcher will always bring their previous knowledge and experiences to the research focus area (Scott & Usher, 1999). Examples of bias of the researcher for this project include being a member of the research location, a long-term advocate for Māori education and having a background in teaching the science curriculum, specifically in Māori medium settings. In case study approaches it is recommended that the researcher checks the validity by first checking the data against the research theory and also how the theory is reflected in the data (Scott & Usher, 1999). The researcher used Kaupapa Māori theory and the research question as a guide to keep their bias and focus of the research in check. This is an example of kia piki ake i ngā raruraru o te kāinga as the researcher used their commitment to and was answerable to the Ngāti Whakaue community as a key validity tool.

Transcribing qualitative data is highly recommended to allow careful analysis by the researcher (Johnson & Christensen, 2008). The researcher transcribed three out of the 14 interviews and focus group discussions to support the thorough analysis of data. Careful field notes and reflections were collated alongside all interviews and focus group discussions. The researcher also listened to some of the interviews again to check for intonations that could indicate participants' real meaning in their response. All participants were given the option to have electronic or hard copies of their transcriptions sent by email or post for them to check. This is a common practice to check the reliability of data (Denscombe, 2003). Only one student made changes to their transcript and only two head science teachers acknowledged the receipt of their transcripts.

4.7 Ethics Approval

The key purpose of gaining ethical approval for qualitative research is for the protection of the participants. Many research-focused institutions have processes and guidelines in place to support the researcher and their chosen participants (Johnson & Christensen, 2008). Ethical approval for this research was given by the Victoria University of Wellington Human Ethics Committee (see approval in Appendix Two). Approval from this committee ensured the researcher's conduct throughout the research process was appropriate and addressed possible ethical issues. Common ethical processes include obtaining informed consent from participants, protection from deception, freedom to withdraw, protection from physical and mental harm, providing confidentiality and/or anonymity, and information concerning dissemination of findings and publication (Johnson & Christensen, 2008). For this research these processes were outlined for participants in information and consent forms found in Appendix Three. Before the data were collected, participants were informed of the research aims and the data analysis process, were given the opportunity to ask questions and given the choice to consent to participate or not. This is an example of sound ethical practice in qualitative research to ensure the research is empowering for participants and the researcher (Merriam, 1998).

This research also followed ethical practices based on Kaupapa Māori theory (Hudson, Milne, Reynolds, Russell & Smith, 2010; Hudson & Russell, 2009; Kidman, 2007; Mead, 2003; G.H. Smith, 2003) and are examples of tikanga or processes and procedures underpinned by Māori beliefs and values (Mead, 2003). Māori concepts including manaakitanga (hospitality), mana (prestige) and whakapapa were the basis of practices employed in this study (Mead, 2003). Manaakitanga was provided for all participants, and schools were acknowledged for their participation (Hudson & Russell, 2009) prior, during, and post-data gathering stage. These included refreshments provided during interviews, book vouchers, for participants and appropriate acknowledgements in publications. The purpose of these considered practices was to ensure the mana of participants was cared for in a holistic manner (Hudson et el., 2010) where their safety and wellbeing were at the forefront of the research. How well the participants were cared for during the research process also had a direct effect on the mana of the researcher for future research projects and her reputation as a representative of not just their university but her whānau, hapū and iwi (Mead, 2003). The maintenance of whakapapa was also fundamental for this research as the relationships the researcher had with the chosen research location and participants is beyond the boundaries of this particular project, which is a common implication for Māori researchers (Hudson & Russell, 2009; Kidman, 2007; Mead, 2003). The researcher aims to continue to build on their contribution to their whānau, hapū, iwi and wider Māori communities (McRae, 2012; McRae & Taiwhati, 2011; McRae et al., 2010) through being involved in future research projects and resulting practical outcomes. Therefore, the continued employment of Kaupapa Māori theory in their methodological and ethical practices is fundamental.

4.8 Research Limitations

The first limitation of this research is that Ngāti Whakaue is only one contributor to the society in Rotorua. There are many other components that have been only partly explored or not included at all in this study that may contribute positively to Māori students' science education. Some of these include the students themselves, their families, friends, sports and recreational clubs, businesses and workplaces, and science organisations. The primary focus of this study is about making a difference for the Ngāti Whakaue community; however, it will hopefully also contribute to the wider Rotorua area. Second, this research is an exploration of some members of the community of Rotorua and their interaction with science education. This exploration has been conducted and interpreted by one member of the Rotorua community. The intent of this research is to share stories from one specific group of people and offer possible opportunities for others in relation to national and international issues in Māori and indigenous science education. Third, the research offers a perspective from only a secondary school setting; however, recommendations are intended to be applicable to all levels of science education programmes working with Māori and indigenous students. Fourth, English and Māori medium settings were chosen as this is the reality of secondary school classrooms in Aotearoa New Zealand. This research does not intend to provide a comparison of the school settings. Finally, the fact that the researcher only met some of the participants for the first time at the time of the interview may have limited what some participants shared because they had not had time to build a trusted relationship. However, for some participants, having the opportunity to share their thoughts with a stranger may have motivated them to be more open, than with someone they interact with everyday who they though they might be judged by.

4.9 Summary

A qualitative approach was chosen and argued for this study as the aim was to explore the relationship between one Māori community – Ngāti Whakaue, located in Rotorua, New Zealand, – and the provision of science education for their students. More specifically, an intrinsic case study (Johnson & Christensen, 2008) with methodological practices linked strongly to Kaupapa Māori theory (Bishop, 2006; Pihama et al., 2002; G.H. Smith, 2003; L.T. Smith, 1999; Walker et al., 2006) was chosen. An explanation was also provided as to how the research question was going to be addressed through the type of data collection, data analysis and coding processes. The chapter concluded with a discussion of the reliability and validity of the research and an explanation of ethical procedures also based on Kaupapa Māori theory, together with the limitations of the study. The resulting findings of this methodological process will be outlined in the following chapter.

CHAPTER FIVE – RESEARCH FINDINGS

5.0 Introduction

This chapter describes the findings that resulted from the analysis of the participants' perceptions explored in the interviews and focus group discussions. It is divided into six sections; each one dedicated to examining the research findings in relation to one of the proposed principles of an indigenous community-based science education programme. These principles are partnership and power-sharing, shared values and aspirations, culturally responsive pedagogy, resourcing, collaboration, and local context. Each section includes: an explanation of what was asked of the participants and why; analysis of key findings of each group's responses, with those of the students presented first, followed by those of teachers, then those of the local elders, in order to privilege student voice initially. Finally, a summary of the section discusses the potential benefits and challenges, and raises further questions for discussion.

5.1 Partnerships and Power-sharing

The first principle, partnership and power-sharing, proposed by this research supports students, teachers, schools and indigenous communities as all being part of the decision making of what is included in science education programmes. To examine the presence of this principle in the context of this study, participants were asked to share their views about the relationship between school science and Māori knowledge. The aim was to identify if what they perceived as Māori knowledge was being included in the teaching of school science and if they recalled being part of decision-making about Māori content in science programmes. The overall finding for this section, was that each group of participants indicated that from their recall of school science experiences, there was little or no inclusion of what they perceived as Māori knowledge. Participants were not specifically asked to what extent they were involved in the decision-making about the input of Māori knowledge in science programmes; however, all participants provided possible ideas and teachers went further to identify what possible support they thought was needed. This finding suggests processes for students, teachers and kaumātua to share their ideas and work together to include Māori content in their science programmes may not have been in place.

Three main themes will be outlined in this section. The first is the nature of examples of Māori knowledge that were included in these participants' school science teaching and learning experiences. The second theme relates to possible school science experiences that were distinctly Māori. The final theme raises questions about resources to support the inclusion of Māori content in science education.

5.1.1 Inclusion of Māori Content in School Science

Students' recall of having what they perceived as Māori knowledge included in their science learning appeared limited and also indicated possible barriers which may have hindered the presence of Māori knowledge in their science programmes. They also identified a range of possible topics that could facilitate the inclusion of their perceptions of Māori content, suggesting that their input in decisions about topics and contexts could be valuable if such input was enabled.

When students were asked what Māori school science topics they were taught, the only response was Matariki, a Māori time of celebrating the harvest new year with the coming of the Pleiades star cluster. These are typical responses given by a quarter of the total group of students:

> Probably Matariki… Touched on it and that was it. (AS3)

> Ae, te Matariki. I āhua whakaatu he aha te Matariki mō Te Arawa.
> (Yes, Matariki. (We) explored a Te Arawa perspective about Matariki).
> (AS6)

Students from one school perceived that there was no inclusion of any Māori topics or content shown by this discussion:

> I don't think I've ever had a science-like topic related to something Māori.
> No. Never had that. Not specifically related to Māori.
> Yeah. Like you can be taught things, write the map to Māori things but saying this is the science behind, you know. But you're given examples but they're only examples. (AS2)

One Māori medium student responded that they learnt science through the medium of the Māori language, which they felt was an example of the inclusion of Māori content. An example of a challenge unique to Māori medium students included having to learn new science concepts as well as having new terms translated into the Māori language. These students praised their teachers for the translation support and providing resources from the library, the Internet and text books. Some Māori medium students learnt school science through the national Correspondence School due to the issue of limited Māori medium senior science teacher capability. Students also praised their teachers for the language and resource support they were able to give in the absence of senior science content knowledge. These students spoke highly of the Correspondence School for its support resources, especially the examples of experiments. Student responses do not suggest that there were opportunities for them to contribute to the selection of topics.

Teachers also gave few teaching examples of including what they perceived as Māori knowledge in their science programmes with less than a quarter giving a response. Their responses indicated that choices and decisions about the focus for science learning were their own, rather than collaborative. However, the majority of teachers were able to provide possible teaching ideas, such as Māori knowledge and use of native flora and fauna, Māori musical instruments, genetics, and the health and well-being of Māori.

One English medium group of teachers from one school gave one of the two total actual examples given, which described the inclusion of Māori context as recognising race or ethnicity, rather than culture as shown by this discussion:

> I use it quite a lot from a medical point of view with particular incidents of Māori and Pacific Islander(s) are more prone to (diseases) than Europeans because of evolution and because of exposure to or not being exposed to certain foods.
>
> DNA… I talk often about families where we've (?) done genetic testing because it's in the whole family and that certain diseases are more prominent in certain races, the Māori and Pacific Island come up quite often so I use that.
>
> I always bring up Polynesians… With diabetes and obesity. Because they changed to a Western diet. And I also use Polynesians when we're doing body types… genetics. We talk about well the theory is that big people survived on the open ocean canoes better. (TS4)

The repeated use of the personal pronoun in these comments indicates that it is the teacher who makes the decisions concerning topic choice. This discussion also highlights an issue concerning the association of race and ethnicity with scientific information as a possible avenue to engage indigenous students. This aspect will be discussed further in the discussion chapter of this thesis.

Responses from teachers from this same school expressed their concerns that the inclusion of what they perceived to be Māori content in their science teaching was a potential risk that could represent racial segregation. These comments are illustrative:

> I don't think there is (such a thing as a Māori topic). I think you can use examples of context to put things in but I'm not a big fan of racially profiling topics.
>
> I think if (you) sell that is just a Māori topic then we're running the risk of segregating when it should be about us as people recognising that there's different aspects, yes it might be a Māori word, but it's all, it's a bird. (TS4)

These comments highlight teachers possibly using unsubstantiated potential racial issues as a default excuse not to include Māori content or perspectives in their science learning, ultimately limiting their students' engagement with different perspectives to only the teacher's own.

An English medium teacher from another school gave the only other example of their actual teacher practice that described a positive outcome in using a Māori context in their science teaching to engage with a Māori student. The teacher shared that they had included Māori content in their teaching through their knowledge of Māori medicinal use of native plants, which appealed to a Māori student in the class, as shown by this narrative:

> Medicinal plants get included because I can talk about that. It was quite interesting, I had quite a low stream (ability) class and we were looking at very basic plants and I just happened to bring some in. And immediately a (Māori) kid came in, 'That's used as a medicine Miss'. And I said 'Yes'. I said 'We've even grown it to give away to some Māori people, because we have a native garden at home. For healing ulcers…

> That relationship right from the very beginning… you can tap into them. (TS2)

This example again suggests that it is the teacher who makes decisions about topics, and that confidence may be an issue. The inclusion of Māori students' knowledge here relied on the student's volition.

Māori medium teachers did not give a clear specific example of what they perceived as Māori content that they included in their science teaching or that they had sought to involve the Māori community in their decisions about topics and content. However, one Māori medium teacher did share that it was their responsibility to include both a Māori and Western perspective in their science learning as shown by this response:

> (My students have) got this idea in their heads that science is only chemistry and it's not something that our old people are any good at, they look down their noses like our old people were absolutely rubbish, so that's my whainga (goal) is to get them to look at the other side of that… so I've (included) European science or people from other countries having science that we do, but that's for me to rangahau (research) and then tell them that so I guess it starts with me. (TS5)

Limited examples were given by all teachers about how they included what they perceived as Māori content in their science learning; however, they provided a range of potential ideas which will be shared in the next section. There was also a sense of teachers wanting support with resourcing and implementation, best illustrated by this comment:

> There is so much knowledge out there from Māori people that you know if we were to look at or if they (Māori) were to look at say you know our curriculums. Oh look you know they could teach this… and give us a lead in. That would be really, really helpful. But we struggle because, I guess it's because we're ignorant, we don't know. (TS2)

Comments like this one, suggest that some teachers were willing to work with the Māori community if processes to make connections with them were more apparent.

Both kaumātua indicated that they had had no Māori topics or content included in their science learning at school and did not indicate that they had been approached for advice about Māori input into their community's school science programmes.

5.1.2 Possible Inclusion of Māori Content in School Science

During discussions about what Māori topics they had been taught, some students suggested that there needed to be more of what they perceived to be Māori content included in their science learning:

> I reckon there's a mean (large) gap in Māori science. I reckon they need to put a bit more in. (AS3)

> Someone should make up Māori science unit standards. (AS3)

When students were asked why they thought Māori science topics were not included in their learning some responded:

> The curriculum
>
> Getting credits
>
> Because teachers are like tied on following what they need to cover and there's no time for other Māori stuff. (AS3)

These comments indicated that the students were aware of the school systems involved in their learning such as curriculum content and delivery, assessment processes and teacher responsibilities, and that these aspects were seen as constraining the possible inclusion of Māori content.

When asked what they considered to be a Māori school science topic, the most common response from students was astronomy:

> (I think) astronomy, because there's heaps of stories where using the stars to navigate their way. (AS2)
>
> I guess astronomy. Because they use the stars. That's how we got here. (AS3)

They also identified a range of other possible topics that included geography, geology, human biology, sports, carving, food, biology, genetics and the inclusion of Māori terminology.

In summary, this group of Māori students showed interest in the inclusion of Māori content in their science learning and provided examples of possible contexts unique to Māori culture, predominantly in the area of astronomy. These included traditional navigation and the Māori harvesting celebration of Matariki. Students could have been probed more as to why they thought it was important to include Māori context in science and what support they thought was needed to implement their ideas. However, these students' suggestions are positive examples of how to possibly engage Māori students in science education through the inclusion of unique Māori contexts and show that they may have knowledge and ideas to bring to collaborative decision-making over the focus and context for science learning.

Both groups of teachers gave a wide range of ideas about how, what they perceived to be Māori knowledge could be included in science programmes. Some Māori medium teachers wanted to support their students with knowing and understanding Māori protocol and knowledge as perceived by their tīpuna or ancestors as well as everyday science phenomena. This response provides a summary of these perspectives:

> I've always thought that (science is) making sense of your world, and (how) our tīpuna made sense of it then we make sense of it now, you

know according to our interpretations of he aha te ao (what is this world)… Everyday activities has a science component to it… So the challenge is taking those activites they (students) do all the time and say here's the science e mahi ana koe (you are doing). (TS5)

One of the groups of Māori medium teachers from one particular school acknowledged the value of students knowing about how their tīpuna engaged with natural phenomena and debated how Māori culture and science relate to each other as shown by this response:

Ka tohua ki ngā kaumātua me aha (We need to look to our ancestors what to do). Like you know the blue snails that were as big as your hands (in) Fiordland and Coromandel. They used to wait 'til they went up the trees, and the winds… they heard a specific sound they decide when to plant what next or (where) to go and do next. That's science. That's Māori science. But we keep getting those two words mixed up (Māori science) trying to, you know how (compare) you lose in translation that they are the same… in the "what's science". (TS5)

This particular group of teachers provided further discussion about the relationship between Māori knowledge and science education shown by these responses:

Ka huri i te pātai i roto i te ao tūroa, ko te Māori kei roto i te pūtaiao or te pūtaiao rānei kei roto i te ao Māori?

(A question for the modern world is, is a Māori worldview part of science or is science part of a Māori world?) (TS5)

So the question is how do you, he aha te whakaaro Māori ka purua ki roto i (ōu) kaupapa pūtaiao (what Māori perspectives can you include in science topics) and really I think it is he Māori kei reira (it is a Māori view), but I don't know pēnā koina, (probably), it is a Māori (perspective) or is it a Māori something in your science? (TS5)

There are big questions that haven't been answered 'He aha nei te whakaaro Māori?' '(What is a Māori perspective?)' And again then you (ask) the next (question) 'He aha te tikanga Māori?' '(What is appropriate Māori protocol?) (TS5)

One teacher from this same school offered a Māori view of genealogy as a foundation for a Māori worldview of science:

Kare he mea tū atu i te whakapapa, karekau tēnā mahi a tātau. Me whakapapa, me mōhio i ahu mai i a, he rite anō mō ngā mea tipu ahakoa whenua, ahakoa moana.
(Genealogy is the foundation, beyond the control of people. Genealogy is essential, to know where you came from, similar to the genealogy of living things whether on land or sea.) (TS5)

These findings indicate that these teachers were possibly struggling with how to teach the science curriculum in a Māori medium setting from a Māori perspective. The questions they asked suggest that teachers were unsure how to make curriculum content and pedagogy decisions on their own, and were looking to others, such as their Māori community, to support them in deciding the best approach to science education.

Some English medium teachers suggested that Māori knowledge could be included in science teaching through context:

> I just think it's anything that's specific to Māori backgrounds. All topics of course can include material. Say you're (exploring the work of) a (forest) ranger and which way you relate it to Māori things but anything can be taught in the right environment. (TS3)
>
> So if you're going to do a study of plant ecology why not choose a native bush and why not use the Māori names for the trees rather than other names. So try and do it contextually rather than separately. (TS4)

Examples of what all teachers saw as a possible Māori context for teaching science included hangi or earth oven, navigation, medicinal use of plants, and the marae or meeting place. One English medium teacher also gave an accurate example of the possible inclusion of Māori tikanga or protocol such as waahi tapu or the placing of a restriction over an area for cleansing or replenishment.

> The tapu (sacredness) on sites, on certain sites, is interesting. It's all part of sustainability putting tapu on a stream area, or tapu on a fishing area to get stocks back (and) unstable land tapu. You can't go there, that's interesting to me. I mean, a lot of people think of tapu as something spiritual or magical or evil but in actual fact, it was used to sustain fishery and flora and fauna and keep people away from dangerous places. (TS2)

The teacher explained they had informed themselves about Māori concepts, through their personal relationship with a Māori community. The fact that he found this learning interesting suggests that he may consider these Māori concepts as potentially applicable to his science teaching.

Both kaumātua saw potential for what they perceived as Māori knowledge to be or have been included in science programmes. One suggested that students could learn about Māori medicinal practices and knowledge about medicinal uses of plants:

> There are some very good remedies that the old people had with regard to health, but there is still room for improvement that the young people can study… maybe they should study, I don't know if they studied what's in those… leaves and all that, what the contents are I don't know. Maybe they can study that unless they've already done it. (K2)

The other suggested using local context, specifically learning about geothermal activity, could have been included in their science learning:

> We could easily have gone down to the pa (village) at Ohinemutu (local area) or we could have got to Whakarewarewa (local area) or you know any of the geothermal places. (K1)

The kaumātua had ideas about how schools could include what they perceived to be Māori content in science, but neither indicated that they had been involved or had been invited to take part in decision-making about local school science programmes.

5.1.3 Possible Support to Include Māori Content in School Science

Students were not asked what support they thought was needed to include what they perceived to be Māori culture in their science learning, but did indicate some possible barriers for their teachers (see Section 5.1.2), including a rigid curriculum that focused on students achieving credits, which did not allow teachers time to include perceived Māori content.

When teachers were asked what support they thought was available them to include Māori topics, some English medium teachers saw a range of limitations, which included: it was unclear whose role it was to include Māori topics; that some online resources were difficult to use; that it was difficult for some teachers to see the relevance; limited textbooks and supporting resources; limited teacher knowledge and capability; and limited teacher professional development opportunities. These barriers indicate that there may have been no clear decision-making or implementation processes present in these schools in regards to Māori content in their science programmes, or teachers were unable to recall examples.

Some encouraging suggestions from teachers included the need to connect with Māori-led initiatives such as the kohanga reo movement and Māori communities.

Local elders were not asked what support they thought schools needed to include Māori content in their science programmes.

These findings show that all groups of participants saw at least potential in teaching and learning opportunities that included what they perceived to be Māori content in their science programmes. However, their responses suggest there was little evidence of these examples actually being taught. It is unclear whether the limited inclusion of Māori content in school science, as recalled by teachers in English medium settings was due to teachers' perceived external barriers, such as limited Māori science resources, or due to teachers' views about the relevance of Māori content in school science. Whatever the reasoning as to why teachers held these perceptions, they each present issues for Māori students, teachers and local Māori in relation to including Māori culture and knowledge in science education.

One key issue is that while some teachers, students and kaumātua had ideas about Māori content that could be included in their science programmes, some English and Māori medium teachers were unsure how to access support or what support to access. Students and kaumātua shared no evidence that indicated they had been asked for or had offered input or support. The fact that some teachers may be unwilling to include Māori input in their science teaching may also hinder any attempt to connect with anyone for support. Support systems for students and teachers would need to be considered if teachers, schools or Māori students' families or communities requested an improvement of the inclusion of Māori in the science classroom. These possible support systems could see the partnership and power-sharing principle in practice if students, teachers and the local Māori community were able to work together to make any identified improvements. Further questions would need to be explored if schools were to implement the partnership and power-sharing principle, such as "What are some solutions to the barriers identified by teachers in implementing a Māori science programme?", "Who initiates, implements and manages these solutions?" and "What partnership and power-sharing practices could support these possible solutions?"

5.2 Shared Values and Aspirations

The previous Section 5.1, examined the presence of the partnership and power-sharing principle, which promotes the involvement of students, teachers, schools and their indigenous communities in decision-making processes of what is included in science education programmes. The shared values and aspirations principle proposed by this research promotes the inclusion of an indigenous worldview in science education programmes, including cultural perspectives about identity, knowledge, and language. Both principles promote the inclusion of indigenous content in science education programmes. However, they differ in that the partnership and power-sharing principle promotes practices about **how** decisions about content in science education programmes are made, while the shared values and aspirations principle deals with **what** specific content is to be included. Unlike the previous section of findings, this section examines the participants' perceptions and understanding of Māori culture on its own with no relationship to a science context. The purpose was to identify participants' experience and knowledge of Māori culture exclusively, which may give more insight to why or why not students, teachers and local elders saw Māori culture having a place in science programmes. Having an understanding of, and engaging with, Māori culture may provide participants access to Māori knowledge and perspectives that could be included in science education. One key finding was that all groups of participants had varied views and understanding of the Māori culture; the student and teacher participant groups gave a wide range of examples of these. Another finding was that some English medium teachers had an understanding of the Māori culture; however, their involvement with it was either minimal or non-existent. Finally, the marae or Māori central meeting place was viewed by students and local elders as the base location of Māori culture.

5.2.1 Views about Māori Culture

To identify students' views concerning Māori culture, they were asked what made Māori culture unique. The most common response was that traditional Māori protocol was still being practised whereas their perceptions were that other cultures were not, as shown by this typical response:

> …We're still practising our culture things and customs… other cultures have kind of died off… for Māori people its like included in everyday activities. (AS1)

Other examples included Māori practices associated with the family unit, the Māori language and the provision of a personal identity. This response is a typical description of how students perceived Māori practices in relation to whānau or family:

> Have a strong sense of community like whānau [family], that's particularly strong in Māori culture… there's also an importance of the passing down of traditions, knowledge, practice and things to ensure that the future of the next Māori culture… really do value the next generation. (AS4)

This student describes how the Māori language was also viewed as a unique part of Māori culture:

> He pai te mea ki te kōrero i te reo Māori. He maha ake ki te kotahi reo anakē.

> (It's great to be able to speak the Māori language. There are many (people) who only have one language.) (AS5)

Finally, a common response to why students valued being Māori was because it gave them a sense of identity:

> We're way lucky… for example like the Aborigine culture how they were stripped of everything, the stolen generation. Whereas with us we're lucky still to say that we have the mountain and awa (river) and marae (meeting house). At least we can still say that's where I come from whereas the others (?) are like oh I don't know where I come from. (AS2)

When students were asked what were unique Māori activities, over half shared kapa haka (performing arts), and the second most popular response was speaking the Māori language, shared by just under half of the students. In summary, the students viewed the Māori culture as unique, defining identity, and relevant, a lived reality, as shown by the range of aspects they identified and their importance.

Teachers from both types of school were able to give a wide range of social, historical, political, environmental and cultural examples of Māori activities they had knowledge of or had experienced. Social examples included the tribal structures, language and food and, in particular, the hangi or ground oven. Historical aspects included stories and navigational history, and political aspects included the Treaty of Waitangi. Environmental examples included

Māori practices of conservation, medicinal practices and unique flora and fauna of New Zealand. Cultural examples included weaving, artwork, performing arts and the welcoming process of powhiri.

One Māori medium teacher summarised her view of the Māori culture as being a unique worldview as described by this narrative:

> Ko te mōhio pea he motuhake. He motuhake te iwi Māori ki ētahi atu iwi. Ētahi atu āhuatanga pea kei te rite ki iwi kē. Engari kia whakaarohia katoa o ngā āhuatanga o te ao Māori he motuhake. Te tirohanga ki te ao.
> (Understanding is unique. Māori are unique to other cultures. Some elements are the same as other cultures. But our perspectives are unique. Our worldview (is unique.) (TS6)

One kaumātua saw Māori culture as having unique origins, but did not share specifically what these were. The other kaumātua questioned the term 'culture' and shared that the concept of love was more important than identifying people by culture. Both shared that the marae and its associated activities, such as family celebrations and tangihanga (funerals), were the central examples of what made the Māori culture unique.

All participants to varying degrees had some knowledge of the Māori culture. Having knowledge of a culture does not necessarily mean that the culture is valued or the knowledge used. The students' responses indicated that they valued their involvement in Māori culture and it provided a sense of identity. The teachers' responses indicate that they were able to describe multiple aspects of Māori culture, demonstrating some knowledge of the culture, but little or no Māori culture was included in their science programmes, as indicated in Section 5.1, suggesting the value and utility of this knowledge may have been unrecognised. Participants were also asked about their knowledge and involvement with Ngāti Whakaue, which will be discussed in Section 5.4 of this chapter.

5.2.2 Involvement in Māori Culture

The most common Māori activities that students involved themselves in were at the marae (meeting place). They also valued their Māori culture as shown by their responses above and involvement in a range of unique Māori activities. Māori medium teachers were not asked how they involved themselves in unique Māori cultural activities as it was assumed that they involved themselves in the examples of the activities that they gave.

All English medium teachers were able to identify at least one activity that they considered uniquely Māori, which shows they have some understanding of the Māori culture, but does not show whether or not they value it. English medium teachers were asked specifically how they involved themselves in Māori activities as the majority of teachers were non-Māori. Just under half of the English medium teachers stated that they had limited to no involvement in Māori cultural activities. Some responses were of a passive nature:

> We're just tourists. (TS2)
>
> As an observer. (TS2)

One English medium teacher did not see their involvement in Māori activities as a priority for their science teaching as shown by this comment:

> (Students) are getting enough exposure to (Māori culture)… I don't know whether we science teachers also have to. I mean it'd be nice, but I've got a list about this long and you know (you have to) prioritise things. And for me personally, they're not a priority in my time. (TS2)

Two English medium teachers shared examples of how their involvement in Māori cultural activities had a positive impact on their relationship with their Māori students. The first involved themselves in school kapa haka:

> I found when I went to kapa haka, a few of my Year 11 students were in it. And I didn't know them before but I go to see them perform and they were the least performing ones in science. But because they knew that I went and they knew that I'd seen them do what they were doing, I could relate to it in, like, physics. (TS2)

The second shared their experience at a marae:

> (A Māori student) decided I was the person she wanted to confide (in). (Through this relationship) I've had (the) experience just going onto the

> marae… which I've found really quite touching because… I don't have anything like that I can hold on to for my own culture… That's the greatest experience that could have even have happened to change your attitude… To get into the culture, understand the culture. (TS3)

Both kaumātua had been involved in all activities based at their marae in Ohinemutu, but one had chosen to retire from kaumātua marae duties.

In summary, the two examples given by English medium teachers above show that involvement with Māori cultural activities enabled them to make connections with their Māori students. However, there was still limited evidence of the shared values and aspirations principle evident in teacher practice. These findings suggest that actual involvement with Māori cultural activities may have supported teachers in building an understanding of the Māori culture as well as seeing value in it. Practical engagement with Māori cultural activities could be made a priority for teachers as part of their science programme.

5.2.3 Marae Viewed as a Unique Cultural Setting

Kaumātua viewed marae as the physical base of Māori culture and knowledge, which suggests that for them marae were the most appropriate settings to teach and learn about things Māori. Students also identified marae as their most common place to be involved in Māori activities. In the previous section 5.2.2 an English medium teacher shared how they had become involved in marae activities through connecting with one of their Māori students and their family. This is one example of the shared values and aspirations principle as the marae is valued as the central location for the sharing of Māori culture by participants of all three groups.

The findings in sections 5.2.1 to 5.2.3 indicate that all groups of participants had an understanding of the Māori culture shown by the range of examples of activities they either knew about or had experienced. The two narratives shared by two separate English medium teachers provided examples of how the involvement of teachers in Māori cultural activities, particularly in unique Māori settings, may improve teacher-student relationships and the engagement of Māori students in their learning.

All participants were asked about student career aspirations and students were clear about their goals and the science involved. Most teachers, both English and Māori medium, had limited knowledge of their students' aspirations and kaumātua thought that young Māori should pursue careers to contribute to their people. This aspect is discussed further in Section 5.3 as it concerns teachers' understanding of students' needs and interests, which form part of the culturally responsive pedagogy principle.

In summary, students, Māori medium teachers, and kaumātua provided evidence of the shared values and aspirations principle in practice shown by the range of examples of unique Māori activities they gave and to what extent they were involved in them. The indication that all English medium teachers had an understanding of the Māori culture and recalled minimal involvement in unique Māori activities, showed a lack of the shared values and aspirations principle in practice. Similar to the findings in the partnership and power-sharing section of this chapter, English medium teachers may or may not be willing to be involved in Māori cultural activities or may not know how, suggesting a possible disconnection between teachers and their Māori communities. These findings have indicated that the marae setting may be a location for teachers and schools to connect with to support the implementation of the shared values and aspirations principle.

Questions raised by these findings concerning the shared values and aspirations principle include, “How do schools go about connecting with their local marae?” and “Who would facilitate and be involved in discussions about what the shared values and aspirations principle could look like in practice?” Also, aside from connecting with local marae, how else could schools support teachers and students with their involvement in Māori cultural activities and how could this involvement support Māori student engagement in science?

5.3 Culturally Responsive Pedagogy

Culturally responsive pedagogy is the third principle proposed in this thesis that promotes the interchange of teacher student roles in science education programmes as a means to understand each other’s’ cultural backgrounds and associated bodies of knowledge. This research proposes that this principle in practice requires that students, teachers and the indigenous community would have to have a clear understanding of, and respect for, each other, each other’s backgrounds and themselves, and the knowledge that each brings to be able work together in science education.

Participants were asked about their experiences and lived knowledge of science in everyday life as well as their experiences of school science to identify what they perceived science to be. Another purpose was to identify how they learnt about what they perceived science to be, from whom, and their preferred ways of learning. The overall aim was to identify whether or not and how participants had experienced or taught culturally responsive pedagogical approaches in science education.

A key finding for this section was that participants provided a wide range of contexts where they perceived they had learnt about science and where science learning could occur in their everyday life outside of the school setting. However, the range of contexts was limited when participants shared their experiences of teaching and learning school science.

5.3.1 Wide Range of Contexts for Learning Science

The most common response from students when asked about how they experienced science outside of school was that science could be seen and occurred everywhere around them. The main example given was the geothermal activity in the Rotorua area where they saw science as the occurrence of natural phenomena, such as geysers and hot pools, and the use of these in processes, for example in cooking. Other examples in relation to the natural environment included processes that students observed, such as those involved with the weather and the growth of flora and fauna. Students saw science as being a part of a range of jobs or vocations but did not give specific examples of what the science was. The students' most enjoyable activities that they perceived involved science were hobbies and sports and identified biological processes, such as nutrition and physiology and also physics processes, such as force.

When asked who they learned science from outside of school, their responses were limited with under a quarter of the students giving a response that culminated in three types of responses; including through their sports club, from technology such as the internet-based video posting application Youtube, and from members of their family. Despite these responses being limited, this finding suggests that students can link science with sources beyond their teacher.

The typical response from both Māori and English medium teachers was that science could be experienced everywhere and favourite science activities were associated with engaging with the environment or sport and leisure. Their reasons were the same as those of students, which included engagement with, observation of, and making sense of, the natural world and human physiology. Some teachers said their enjoyment of purposefully looking for what they perceived science to be in the world around them supported their science teaching. The following narrative was typical:

> Because as a science teacher… it's just everything and it's not just, kind of the interest of seeing things and thinking oh why does that do that… I'm always thinking, oh right, is this something I can use? I can bring into a classroom, whether it's a leaf or a rock or something I've seen. (TS1)

The fact that some teachers connected their own background and experiences as contributing to their perceptions and enjoyment of learning and teaching science is encouraging for the possible implementation of the culturally responsive pedagogy principle. If teachers see connections between their own lived knowledge and science, then they may have or they potentially could develop the ability to consider the lived experiences and perceptions that their students may have, which could be an example of this principle in practice. All teachers shared that they learnt about science mostly from family members, through schooling or university, through books or from television. Like students, teachers experienced learning science from a range of sources which they could potentially implement in their own teaching as part of a culturally responsive approach to science education.

Both elders linked science to the physical environment, one specifically to the geothermal activity located in the Ngāti Whakaue village of Ohinemutu and the other with weather phenomena. For one elder, their favourite science activity was birthing and for the other elder it was geothermal activity. Both learnt science from older family members by discussing everyday natural phenomena around their immediate environment as described below:

R: Who did you learn about science from outside of the classroom?

K1: My Nan.

R: What did you learn from her?

K1: Again I have to go back to the thermal activity because it was part and parcel of her life and other members of Ohinemutu. Because some of us didn't have access to electricity to heat water so we made use of the thermal resources.

In summary, the majority of participants, more specifically the groups of students and teachers, were able to link science with contexts outside of the school setting; however, no examples that they considered to be a Māori context were given. The closest examples to a Māori cultural context that participants said involved science were the geothermal activities, which are a dominant part of the local context of the research setting. Specific examples included learning about geothermal ecology, sulphur, hot pools and the use of geothermal energy for cooking and heating.

All groups of participants shared examples of enjoying learning science in the physical environment. Common responses included popular geothermal areas, forests and waterways in the Rotorua area. A holistic approach to teaching science through acknowledging other related perspectives, such as a cultural one, could be a potential culturally responsive pedagogical topic for science teaching and learning.

5.3.2 Teachers Influenced Enjoyment of School Science

Participants were also asked about their experiences of school science, again to establish their perceptions of science, to identify the inclusion of a Māori context, and to identify their preferred ways of teaching and learning school science. The key finding where all groups of participants had similar perceptions was that their enjoyment of school science depended on the teacher. Participants stated that an engaging teacher was knowledgeable, committed to their students' positive engagement, and used a range of strategies to meet their students' needs. This type of teacher reflects the culturally responsive pedagogy principle in that the teacher would have to build good relationships with their students to be able to identify their needs and preferred learning styles.

Students appreciated teachers who were easy to talk to, were understanding, gave extra time, were direct in communication but not negative, and pushed them beyond their own expectations. The three students who learnt through correspondence, as indicated in the teacher and focus group discussions, appreciated the support their teachers gave them there. Students also respected teachers who were experienced and knew what they were talking about. This excerpt from one student focus group discussion summarises common responses:

> …if you don't like your teacher you're not going to class.
>
> I can relate to that now.
>
> That's a huge thing for me. If I don't like the teacher I won't go.

> The way they treat you.
>
> I reckon how enthusiastic the teacher is maybe.
>
> Like you can tell when a teacher knows (their content). (AS2)

Some students stated that books were their only reliable learning resource, as they felt sometimes support from teachers was not very forthcoming or that teachers expected them to just understand, as shown by these comments between two students:

> It's the only resource that you can actually rely on.
>
> Because if you ask the teacher they just look at you like really you weren't listening in my class. It's kind of hard. (AS3)

This discussion indicates that students had limited engagement with their teacher or teachers. Positive relationships in the classroom are fundamental for the implementation of the culturally responsive pedagogy principle.

Students enjoyed a topic when everyone in the class was involved in learning and working hard together, when they were pushed beyond what they expected of themselves and got extra support from teachers as shown by this discussion:

> …he taught us all as a group to do excellent work and so by doing that we were able to like write excellent answers and like pass our papers with ease. I found that easy because… it allowed us to learn more than we should.
>
> Yes. Yeah do more.

> … gave us higher understanding so we knew like things that the other class didn’t…
>
> I mean all teachers offer me extra tutorials and stuff, which is quite good as well if I don't understand something.
>
> You see them frequently because you’re more or less seeing them every day and it’s kind of just this constant push to do well in science. (AS4)

One group of students said their science class would be more enjoyable if their teacher changed their delivery style, as shown by this discussion:

> If science was taught in a more enjoyable way, if they taught it, I don't know, in a fun way.
>
> Then it would be… way better. And if they had more activities for us to do.
>
> Instead of just like copying off the board and then listening to (them) and (not knowing) what the heck are (they) going on about.
>
> (Comments about teacher incorporating cartoon clips to support class content)
>
> It’s good for the students because they’re like yay I’ve finished listening to your monotone voice now I can listen to someone enjoyable. (AS3)

Students identified that having a good relationship with their teacher was important for science learning, which involved clear communication about their needs and teacher expectations. They also appreciated a teacher who had both strong content and pedagogical approaches and who showed commitment to their students by giving extra time. Some students said they had to rely on other learning resources as they felt they could not rely on their teachers.

Teachers had similar responses and said they learnt most in school science from teachers who were passionate, knew their topics, varied their pedagogy, and knew their students.

Both kaumātua enjoyed the support they got from their teachers, but would have liked to have had opportunities to learn science outside of the classroom, which neither of them experienced.

In relation to the culturally responsive pedagogy principle, these findings show that there may need to be some improvement in teacher–student relationships. Student comments have suggested that some teachers need to take the time to get to know their students and their needs, and explore pedagogical practices that support identified student needs.

5.3.3 School Science In or Out of the Classroom?

A key finding was that teachers and kaumātua advocated for learning school science outside of the classroom; however, most students saw school as the central location for learning school science and expressed no strong desire to be taught outside.

When participants were asked about their experiences of learning science outside of the classroom, the most common activity identified by students was field trips, though these were identified by less than a third of students. Other examples included open days at universities or science institutions, school-based activities, such as experiments in the school grounds, study at school, and books. Television programmes were the only home-based example. Physics and chemistry-based activities were experiments performed on the school playing fields. Biology-focused field trips were the most common, based at the research location of Rotorua on waterways and trips about geothermal activity and geology were experienced by over half of the students. Sulphur reactions was also a chemistry topic some students had been involved in. A few students shared that the local mountain, Tarawera, was included in topics exploring volcanology or geology. Other locations outside of Rotorua that students visited for science field trips included a marine reserve in the north of New Zealand, a major river north of Rotorua, and visits to universities in the main northern cities of Hamilton and Auckland.

Despite their common experience of field trips, most students preferred to learn science at school; however, some of those students agreed with the students who preferred to learn outside that there was some benefit to learning science outside of the classroom. Reasons given for preferring to learn at school included fear of getting distracted if taught anywhere else, fear of not being able to achieve their credits, feeling like they were just having fun and not learning anything, having no clear learning focus, or absence of a controlled learning environment. Students also appreciated the support at school and preferred to do their homework at school to get support from peers and teachers and to use the library.

The responses from those students who preferred to learn outside were not as varied as those about learning inside; the most common response was being able to see and interact with what was being taught, as this discussion describes:

> You're actually not learning it, you're not seeing it happen… you only read it… so that must happen but you don't actually see it.
>
> That's probably how I learn.
>
> It's a whole lot of memory stuff. Like it's not put into use, it's like you just know it but it's never going to be.
>
> You're never going to see it in real life.
>
> Unless you go to Africa or something.
>
> Yes because you learn about those animals, weird animals.
>
> You don't learn about animals you live among. (AS3)

Two students gave detailed examples of engaging in science outside of the classroom that was involved with their home life. The first example was a student who attended an aviator club, which seemed to be important to this student as they made reference to it a lot during their focus group discussion. An example is given below:

> I'm part of the air training corps and we talk a lot about like lift and pull, you know how to get a plane off and stuff… that's another activity that I like that involves science. (AS1)

The other example was a student who showed an interest in astronomy, so much that their mother bought them a telescope as described here:

> For a little while I was a bit interested in astronomy and I got a telescope and everything… looked through that and kind of just see what's going on outside, all the stars and stuff. (AS4)

Teachers gave examples of where they had taught science outside, including field trips in a variety of natural habitats in New Zealand as well as zoos, museums and science institutions. Field trips were not a common occurrence in all participating schools. Similar to the students' responses, each group of teachers stated that these trips were rare and usually an annual event for only certain science subjects and for certain levels of students. Over half of those who were asked about where they preferred to teach school science chose field trips; however, they also shared that these were limited due to lack of funds, planning, and preparation, and managing new safety procedures. When asked specifically how teachers included Rotorua-based issues or topics in their science teaching, the responses were mainly about topics they would like to teach but felt they could not teach due to the issues just mentioned.

One elder shared that school science should be taught out in the field, especially with regard to environmental issues in the local area, while the other thought that programmes should focus on the health and wellbeing of Māori.

In summary, these are interesting findings in that the students' and teachers' responses are contradictory. The students' responses suggest that for many there was minimal, with only a third having experienced science learning outside of the classroom. The students may have responded that they preferred to learn science at school only within the school location, but for some this may be the only approach that they had experienced. These findings also suggest that even though some teachers would like to teach science experiences outside of the classroom, some barriers may exist or perceived to exist for this type of learning.

The inclusion of experiences outside of the classroom, though not overly common, shows some potential for culturally responsive pedagogy, as teachers could create learning opportunities that relate to not only their students' needs but also their outside interests. These learning experiences may also include the teachers' personal interests and outside networks and connections. This approach would involve teachers having good relationships with their students as a means of knowing what their needs and interests are. It may also extend to connecting with their students' families and communities to support teacher understanding of their students.

5.3.4 Mixed Knowledge and Views about Career Pathways

Although students themselves were clear about aspirations and their needs regarding science subjects, responses show that teachers were less sure of individuals' aspirations and needs with regard to science subjects. There was a diverse range of prospective careers identified by students, pursued through either tertiary study or the armed forces, including engineering, sports science, aviation, environmental studies, architecture, medicine, hospitality, psychiatry and psychology, health, pharmaceuticals and veterinary science. All students were able to identify the science subjects involved in their prospective careers and what subjects they needed to take to work towards these career pathways. The most common response as to where students sought and gained career support advice, was from career advisors, as shared by over half of the students. Other responses given by a few or some students included seeing and gaining advice from teachers, parents, wider family members, and from attending career expos.

Students' motivation to pursue a science-related career was influenced by wanting to make a contribution to Māori and support from their parents, wider family members, and peers. The following narratives provide some examples of these influences:

> With the Māori battalion (WWII battalion)… how they gave up their generation… I feel like we should be paying our ancestors back by doing something good with our lives… giving back to the community… (AS1)

> I want to like work for my iwi (tribe)… because our water and stuff's been taken… the council's trying to take it and… it's destroying us kids so I want to help towards that if it's still going on when we're older. (AS2)

> My koro (grandfather) pushes me to like gain the best education that I can and I think that's because some of the opportunities that are available now to us now weren't available to them back then. (AS1)
>
> Want to be better than your mates (AS1)

The two main types of careers that teachers thought of or knew their students wanted to enter were medicine and veterinary science, with other careers including sport, trades, engineering, architecture, information technology, forensic science, and marine biology.

Teachers had mixed views about their students' career aspirations. One group from an English medium school was unclear about who their Māori students were, but knew some overall school roll statistics, as shown by this discussion:

> Have to look at my list you know.
>
> It's hard to differentiate.
>
> I've got, in fact I don't have one in my senior bio class and I have one out of 32 are Māori.
>
> Have you checked out the percentage for the whole school?
>
> We're 33. (Conferring discussion)
>
> Seventeen I think 17%; we're really down because we get a lot of PI (Pacific Island) students.
>
> We used to be 33.
>
> But not actually Māori. (TS4)

Some teachers thought that parents were an influence on students' aspirations in both a negative and positive way:

> One of the huge limitations is still from Māori parents themselves who maybe don't understand the pathways and limit their kids in terms of what they can do… (we need) the wider whānau (and) more young people coming in now and encouraging other young people to go and do things. (TS3)

> I don't think they (two particular boys) get support, they just don't have that encouragement, they don't have any expectations at home. Like (one boy's) Dad I've seen him, he's a road worker and like he would never have (completed secondary school) he wouldn't have a clue what (his boy) is doing. (TS4)

> His mother is very supportive and he is very bright. He's a very good student. (TS4)

Some teachers stated that encouragement from others was definitely great support for students:

> I've seen kids come from getting 20% in (school) science and doing physics at university. It's all about understanding and encouragement and other people around them believing they can go and do it. (TS3)

One teacher shared that they had observed some Māori students who were now contributing to their affiliated tribes' development with their science knowledge in combination with other disciplines they studied at university:

> They may have gone (to university) and done a law degree but the law degrees (also involved some) science… they are now in (a position) where they can further the hapū and iwi land developments and the sort of scientific things on board. (TS3)

This participant gave a specific example linked to Rotorua:

> …this whole movement now… using geothermal power and realising that then they've got great resources; young people are coming in and really pushing that sort of thing and understanding why it should be pushed. (TS3)

The teachers' responses suggested that in-school career support for students was varied. Examples included regular, one-on-one discussion between students and career advisors and teachers providing information about career pathways. A few teachers reported that unclear information was sometimes given by career advisors.

Both kaumātua thought that young Māori should aspire to careers in health, again to support the health and wellbeing of Māori:

> Yes in health because it's such a big umbrella; again it involves people. You know it covers the whole health…The food, the work and I guess that's another area under science stuff. Work, we have so many people [Māori] who don't work. (K1)

Some of these findings are contradictory to the culturally responsive pedagogy principle, which promotes teachers having a good understanding of their students' needs and interests. Again, there may be barriers as to why this group of teachers was unclear about their students' career goals and subsequent needs, but it is a concern especially when teachers themselves shared that the role of the teacher was an important part of student engagement with school science (Section 5.3.3). The mixed knowledge and understanding of students' science aspirations indicates a possible need for more communication between students, teachers and families. Some students and kaumātua agreed that making a contribution to Māori was an important career aspiration for students, which is an example of close and reciprocal relationships and awareness that both groups can influence and inspire each other, as well as an example of shared aspirations (section 5.2). The place of relationships between Māori students and local kaumātua in science programmes is an area to explore as a potential strategy to ensure positive engagement of Māori students in science education. Kaumātua and other outside agencies, such as science organisations, could be part of the practical experiences exploring Rotorua that some schools included in their science programmes.

Further questions need to be explored and discussed if schools were to implement the culturally responsive pedagogy principle in their science programmes. These may include: “How do teachers learn about their students’ backgrounds and aspirations, and include this knowledge in their science teaching?” and “How do teachers and students explore and share with each other what they perceive science to be?” Also, if local context and issues were to be included or their inclusion improved upon in the delivery of school science, the question is raised about how schools access local indigenous knowledge? The next section has provided some insight into this question.

5.4 Resourcing

The resourcing principle is the fourth component of the proposed indigenous community-based science programme, which advocates schools accessing a wide range of resources to support the inclusion of indigenous knowledge in their science programmes. The resourcing principle in practice in the research setting of Ngāti Whakaue would see schools accessing and engaging with local resources, such as the physical environment, local activities, and knowledge such as history and stories. Participants were asked about what resources they would access or need if Ngāti Whakaue was a part of their science programmes. A key finding for this section was that all groups of participants had ideas about how Ngāti Whakaue could be included in school science and some ideas about possible supportive resources. Some students and teachers had limited knowledge or engagement with Ngāti Whakaue; however, kaumātua had strong knowledge and engagement.

5.4.1 Mixed Knowledge and Engagement with Ngāti Whakaue

Being of Ngāti Whakaue descent was not an applicable factor when exploring participants' knowledge and engagement with Ngāti Whakaue. The important factor was that participants were living, studying and teaching in the Ngāti Whakaue area. Less than a quarter of the total students affiliated themselves with Ngāti Whakaue. Fewer than half of the students gave an example of a story that they related to the Ngāti Whakaue village of Ohinemutu. Examples were associated with Ngāti Whakaue and Te Arawa ancestors, including Tunohopu, Pukaki, Te Whanoa, Ihenga, Hinetekakara, and Hinemoa and Tutanekai. Students shared that they had learnt these stories through kapa haka groups, learning haka, attending kohanga reo (Māori language nest), from books and television, at primary school, and from parents. A few students gave examples of past and present issues associated with Ngāti Whakaue, including conflict with tourist ventures, algae, lake pollution, and the revival of marae. When asked about what further support they needed to learn about these issues, students identified kaumātua and the local city council.

Over half of the students saw the potential of school science being taught at Ohinemutu. Common topics they suggested included learning about sulphur, mud pools, plants, photosynthesis, converting geothermal energy, and cooking. Other topics students associated with this area also included water health and pollution, which students thought could be integrated into geology, chemistry, biology and physics. Two students reported that they had visited Ohinemutu for school tasks, including a leadership camp, and to view rocks for a science class.

The teachers' knowledge of Ngāti Whakaue ranged from not knowing anything at all to knowing about the history of the settlement, the main wharenui or meeting house of Tamatekapua and some stories they had learnt from a local historian. Teachers shared examples of geothermal activity in the Ngāti Whakaue area, which they saw as potential science teaching topics. Other possible topics included Māori carvings, water studies, and genetics. Support systems that teachers thought they needed to incorporate Ngāti Whakaue-related topics in their teaching included stories from kaumātua and online resources.

Both kaumātua were knowledgeable about a range of past and present stories and issues related to Ngāti Whakaue and advocated the importance of learning, knowing, and sharing these stories with others. They both gave examples of how school science learning could occur based around Ohinemutu, including geothermal-related activities and environmental issues. Ngāti Whakaue specific issues they thought needed to be taken into consideration by Ngāti Whakaue, included infrastructure issues with local government, management issues with tribal resource trustees, and reviewing of Māori protocol practices. One kaumātua saw managing water pollution as an important issue that involved science and was important for young people to be involved in studying. They identified the local council as a possible support system for students to learn about the Ngāti Whakaue physical environment. Both wanted to encourage their own children and grandchildren to be involved in learning about these issues.

The fact that all groups of participants had ideas about how Ngāti Whakaue could be used as a resource in school science, is encouraging for the development of science programmes that include indigenous locations, as a means to support indigenous students in science education. All groups of participants described a range of possible teaching topics that could be based in the central Ngāti Whakaue village of Ohinemutu and all groups also had a range of ideas about how students, teachers could be supported in the implementation of these topics. However, limited or no actual school science was happening in Ohinemutu and some students and teachers had limited knowledge or no engagement at all with Ngāti Whakaue. It is unclear whether the limited inclusion of Ngāti Whakaue is due to teachers' perceived external barriers; not knowing how to access support; teachers' views about the place of things Māori in school science; or never having thought about Ngāti Whakaue as a resource in their teaching.

Participants identified some possible resources and processes that could support schools to include a Ngāti Whakaue context and local resources in their science programmes. The implementation of these ideas would be examples of the resourcing principle in practice as Ngāti Whakaue would be accessed for support with science programmes. Further questions would need to be explored if schools were to implement this approach, such as: "How do schools and Ngāti Whakaue work together to resource science programmes to meet the needs of their students?"

5.5 Collaboration

Section 5.1 of this chapter explored the extent to which the participants implemented the partnership and power-sharing principle that promotes students, teachers, schools and indigenous communities are all part of the decision making processes of what content is included in science education programmes. A key finding from that section suggested that processes for students, teachers and kaumātua to share their ideas and work together to include Māori content in their science programmes, may not have been in place. Similarly, the collaboration principle in practice promotes collaborative processes and systems to ensure the implementation of **both** indigenous and science bodies of knowledge in science education programmes. The collaboration principle complements the partnership and power-sharing principle as it requires that students, teachers, and schools see a complementary relationship between the two bodies of knowledge and working collaboratively with Māori communities to develop and implement their science programmes.

Participants were asked about their perceptions of the relationship between what they perceived to be Māori knowledge and science in their everyday lives. These questions differed from those asked to explore the partnership and power-sharing principle (Section 5.1) which examined the participants' perceptions of the relationship between Māori knowledge and **school** science. These questions are also distinct from those used to explore the culturally responsive principle (Section 5.3) which examined participants' science in everyday life and school science on their own.

Participants predominantly gave further responses to **what** Māori content could be included rather than **ways** teachers could work collaboratively with Māori communities. This finding provides further evidence that participants have an understanding of possible teaching and learning opportunities that acknowledge both Māori and science content, but need support to know how to go about making this happen. Participants did offer one possible pedagogical approach, which was the exploration of Māori stories, legends, and history. The sharing of stories could be a successful collaborative practice as an opportunity for students, teachers and Māori communities to share their backgrounds and perspectives.

Kaumātua again suggested the use of marae as the key location for teaching Māori science education. As suggested previously (Section 3.3.5), marae could be a collaborative location for students, teachers, schools and Māori communities to work together in implementing indigenous community-based science programmes.

5.5.1 Examples of Māori Content and Science

The collaborative principle in practice (Section 3.3.5) first requires students, teachers and schools to identify activities that include both Māori and science bodies of knowledge and then work collaboratively with Māori communities to develop and implement their science programmes. A Māori activity where students saw the application of science was the making of a hangi (earth oven) to include science ideas involved in topics such as nutrition, occurrence of chemical reactions, use of the earth, and use of energy. The next most popular response was kapa haka (Māori performing arts) to include science ideas such as the use of kinetic energy and body movement. Other responses included Māori uses of and practices within the environment, including agricultural uses of land, fishing and navigation.

For English medium teachers, hangi, food and cooking were the most common examples of a Māori science activity with links made to physics, geology, and chemistry. Other examples included the poi, or the Māori performing art that involves the swinging of stringed balls, that could involve physics teaching about motion. They also shared environmental examples, such as eeling, flax use, and medicinal use of plants. Other examples included navigation and tāmoko, or the art of Māori tattoo.

One Māori medium teacher shared an example of what the collaboration principle could look like in practice:

> Ia rua tau ka haere te kura ki tētahi o ngā puke i Ngongotaha nei. I te atatū ano ki te mātaki i a Matariki i tona wā. Tae atu mātao rawa i ngā hukapapa ēra atu āhuatanga katoa. Ana, he tino mahi, ka tae atu te whānau katoa, nā reira ehara i te mea ko ngā tamariki noa iho. Ka haere hoki a tātou mātua. He wā poroporoaki ki ngā mate, he mihi mō te tau hou, he mihi ki a Papatūānuku, ēra āhuatanga katoa. Engari, kei te

maumahara hoki au i tētahi wā, i te kura tonu ahau. Ana i aronui mātou i ngā whetū me te nekehanga o ngā whetū. Nā (tētahi tohunga Māori o te pāngarau) tērā i ārahi i te whānau. Nā reira, nana (me tētahi tohunga Māori hangarau) nā rāua te whānau i whakangungu ka whakaritea he wānanga.

(Every two years our school visits one of the peaks on Mount Ngongotaha (a significant local Rotorua mountain). We go at dawn to observe Matariki (the Pleiades star cluster). It's freezing from the frost. It is an important occasion for our whole school community not just for our students. Parents go too. It's a time to remember those who have passed and welcome in the new harvest year. I remember when I was still at school. We were focusing on astronomy. A Māori mathematics expert came to support our community. They and another Māori technology expert came to teach our school community through a shared hui.) (TS6)

This collaborative science teaching and learning example involved students, their parents, teachers, and the wider school community, and experts, working together. It also involved Māori perspectives and practices associated with the local environment. This school showed commitment to this approach as it was stated that this was a regular biannual event. It was also possibly a long-term commitment as the teacher said they had participated in this approach when they were a student at the school. This commitment could allow future collaborations with a range of experts, other schools, and communities. There is also a high possibility that the sharing of stories by the school community was encouraged, including scientific, historical, experiential and cultural accounts.

5.5.2 Story-telling as a Possible Pedagogy

Story-telling is a common collaborative practice in many indigenous cultures as a means of making meaning of the world around them. All students were asked whether they knew of a Māori legend or story that they thought involved science activities, with under half providing an example. However, the examples provided are useful. The local Rotorua love story of ancestors 'Hinemoa and Tutanekai' was given as an example of involving science due to the physics concepts of air pressure and sound involved when Tutanekai plays his flute for his lover Hinemoa. The legendary battle of 'Tamahoe and Ngātoroirangi' atop Tongariro (a local mountain) over claiming geothermal energy was also given. This example, as well as the historical eruption of the local mountain of Tarawera of 1886, was shared by students as involving scientific geological processes. The Māori demi-god Maui was also mentioned due to his famous legend of slowing the sun, which students thought could be connected to atmospheric processes and phenomena. Students had varied thoughts about the scientific validity of these stories as shown by these narratives:

> It's kind of hard to put science involved with the Māori legend because we've always been told that it was caused by this instead it was caused by a scientific thing. (AS2)
>
> Well Maui we always thought that he slowed down the sun.

> (But) when you look at it scientifically the sun was always slow.
>
> Yeah so scientifically that would be impossible. (AS2)
>
> …how New Zealand is shaped… things like that from (stories) and it really does reflect they (Māori) did have some knowledge of the science, of the geography. (AS4)

These examples of student responses present a dilemma for students and teachers if the use of Māori legends was to be promoted as a way to implement the collaboration principle. This assumption could be supported by some English medium teachers sharing that they found it difficult to make connections between Māori knowledge and science education. This was a typical response:

> That's where I find it difficult. I mean the science from a story like that (Maui stories) I mean science is conflicting. (TS1)

These types of responses are another example of teachers possibly just wanting to know how to incorporate Māori content and pedagogy into their science classroom and how to access appropriate support and resources. The range of students' knowledge about local history and legends is encouraging in that teachers could use this knowledge as a pedagogical approach to recognise student prior knowledge and explore the nature of Māori and science knowledge from each other's perspectives. This issue and related tensions will be discussed further in the final chapter of this thesis. Kaumātua again offered the marae setting as a possible support mechanism.

5.5.3 Marae as a Base of Māori Science Activity

When asked about Māori stories that related to science phenomena, one kaumatua shared how their grandmother at night while in the hot pools told stories about comets and stars. This same kaumātua also shared that they learnt many stories from elders as they went about their daily activities. One common activity based at the marae where one kaumātua perceived science to be happening was during tangihanga or funerals, as described by this narrative:

> In the preparation of food whether it be gathering or going and getting watercress or puha… That's all part and parcel of the science of health and wellbeing because you have to be very disciplined about hygiene with the food otherwise there have been occasions when people that have got ill from ill-prepared food... they go to the moana (sea)… that's a science in itself… it's just a chain reaction. You know you can just hone in on one activity and another one would be you know getting mussels, getting the fish, smoking it… hunting and getting a pig or two. (K2)

These findings provide further evidence that all participants saw at least potential opportunities to include both Māori and science knowledge in science education; however, some participants still questioned whether Māori and science knowledge had equal validity in the science classroom. This highlights the tension about the place of the two knowledge systems in the science classroom. For example, some students' perceptions of Māori legends were that they were completely fictional and science content was fact. These findings also provide further evidence of the varied extent to which all participants value and appreciate the differing nature and purposes of Māori and science knowledge. This research has already identified that students' perceptions of relationships with teachers influence student engagement with school science. Teachers' views about relationships, if any, between Māori and science knowledge may potentially influence Māori student perceptions.

Kaumātua again saw marae as the base of Māori knowledge. Schools could consider marae as collaborative locations to deliver science programmes where Māori content and pedagogy, as well as other perspectives, could be explored with students, teachers, and local Māori. Marae could also be a possible location to discuss perceived issues of tension and conflict about the inclusion of both Māori and science knowledge in the science classroom. Further questions would need to be examined if schools were to implement this approach, such as: "Who initiates, develops, manages and reviews collaborative practices between schools and Māori communities?" and "Who manages the delivery of Māori and science knowledge in school science?"

5.6 Local Context

The local context principle is the final component of the indigenous community-based science programme identified in this thesis, which supports the inclusion of local phenomena, community resources, and local issues in science education to ensure positive engagement by indigenous students.

Participants were asked about their perceptions of place and, more specifically, the research location of Rotorua to examine the presence of the local context principle.

The key findings for this section were first, that all groups had knowledge of the Rotorua area. Second, they viewed Rotorua as a unique location where the geothermal environment and Māori culture were the main contributors to the cultural, political, economic, historical, and social aspects of the city. Third, all groups of participants also had an understanding of having a connection or belonging to a place and associated this connectedness with spending time with family and friends. These findings show some evidence of the local context principle in that participants had knowledge of local phenomena, resources and issues. However, similar to the findings from the examination of other proposed principles, there was again limited evidence of this principle in practice and some disconnect between students, teachers, and Māori communities.

5.6.1 Participants Had Local Knowledge of Rotorua

Similar to findings in Sections 5.1 and 5.5, most students were able to provide examples of legends, stories and historical events associated with Rotorua. These included the famous love story of ancestors Hinemoa and Tutanekai and the historical event of the Mount Tarawera eruption of 1886. The legend of Te Arawa high priest Ngātoroirangi bringing the geothermal activity to Rotorua from legendary Hawaiki was also shared. The myth of ancestor Hatupatu and Kurungaituku the bird woman, the story of Te Arawa explorer Ihenga and the patupaiarehe (fairy people), and the historical hot pools of Hinehopu were other examples. Students learnt these stories at kohanga reo (early childhood language nest) or primary school from parents, grandparents, books, at the marae, at the museum, and through songs.

Most teachers, including both English and Māori medium, shared stories about Rotorua, including legends and accounts of historical battles and events of the Te Arawa people. Both types of teachers learnt these stories from their parents, books, field trips, school or local experts. Both kaumātua knew a range of historical stories about Ohinemutu and Ngāti Whakaue that were learnt by listening to family members. Both said they shared these stories with their children. The famous love story of Te Arawa ancestors Hinemoa and Tutanekai was the only specific local story given by one kaumātua:

> The most famous one is the story of Hinemoa and Tutanekai and hearing about the Tarawera eruption but mainly just about living at the pa (village) and listening to stories from my family, aunties, uncles, cousins. (K1)

In Sections 5.1 and 5.5, some teachers expressed that they just wanted to know how to implement Māori content in their science teaching. In Section 5.5.2, story-telling was identified as a possible pedagogy for teachers to include in their science classroom. Story-telling about local history, Māori legends and significant events appeared to be an activity all participants enjoyed or were involved in as part of their informal and formal learning with peers, teachers, family members, and experts. The sharing of narratives about places important to students, teachers and the local Māori community could be an engaging approach to include local Māori content in the science classroom. Diverse backgrounds, knowledge, perspectives and views could be acknowledged and validated through allowing opportunities for each group's stories to be told as part of science programmes. In relation to the local context principle, narratives about local history, resources, environment, and issues could be a part of this approach.

5.6.2 Participants Viewed Rotorua as a Unique Environment

All groups of participants viewed Rotorua as a unique and significant location for themselves and others, shown by the variety of types of geothermal, historical and cultural places that they shared were important. Students thought that these locations provided examples of Māori culture and history of Rotorua, as well as science activities. One example was the Rotorua Museum of Art and History located in the historical thermal attraction of the Bath House, which contains Te Arawa treasures, fine arts, photographic collections, social history collections, and an education programme:

> Rotorua museum, there's like a lot of like historical things there, it's like a good learning curve. It teaches you a lot about Rotorua and its history. (AS1)

Another example was the thermal village of Whakarewarewa located in southern Rotorua, which has tours that highlight Māori history, culture, and geothermal activity.

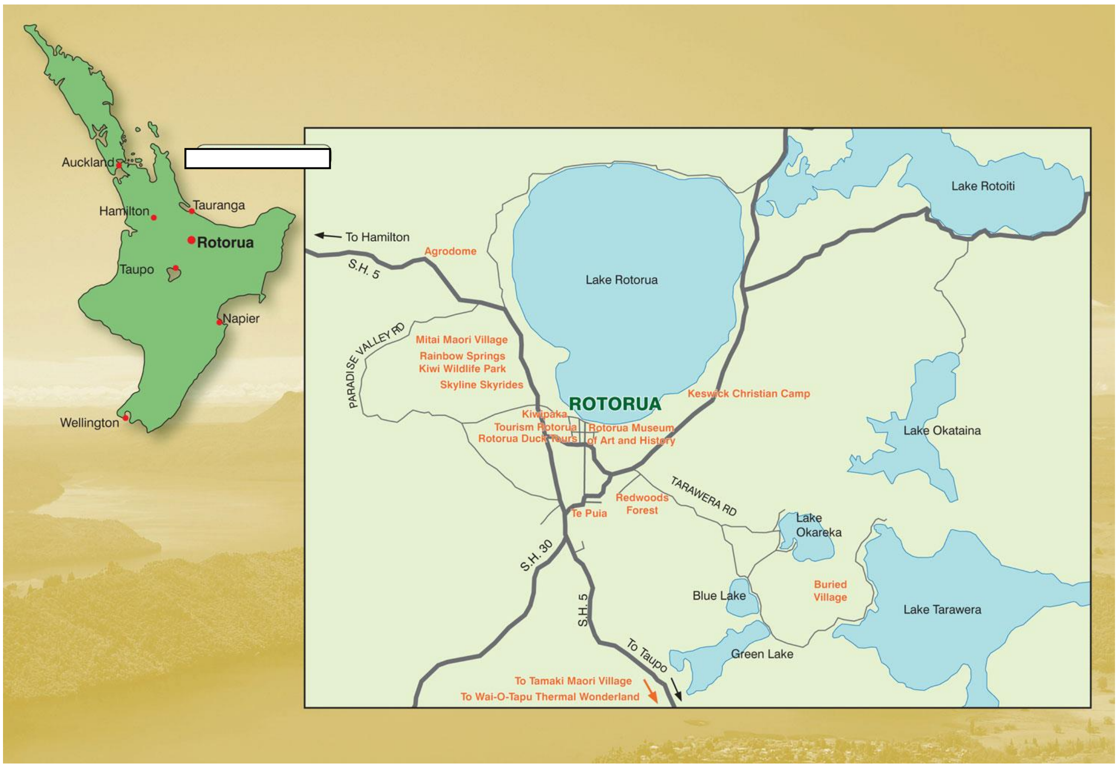
> Whakarewarewa (a geothermal village) because you get to experience the Māori culture. (AS3)

Both Māori and English medium teachers provided a wide range of examples of what they thought were significant places in Rotorua. Most teachers thought that geothermal areas in Rotorua were significant, as well as parts of the natural environment, such as lakes, streams or a particular mountain. Other significant places included Māori cultural, historical, and adventure tourism venues.

Both kaumātua chose the local Māori village of Ohinemutu as a key place to visit for all of the same reasons given by the teachers.

Specific locations that students thought were significant included the village of Whakarewarewa, the small communities of Rotoiti, Ohinemutu, Hinemoa Point, Awahou and the lakefront area of Lake Rotorua (Map 5.1). The main response as to why students shared these places was spending time with family at them.

Map 5.1: Significant locations in the wider Rotorua area



In relation to the local context principle, participants provided evidence that Rotorua is a potentially rich learning context (Sections 5.3 & 5.5) to include in a science programme, where students and teachers could explore a range of perspectives including scientific, physical, cultural and historical.

5.6.3 Participants Associated Place with Being with Others

The students' most commonly identified favourite places to spend time were in Rotorua. A typical response as to why they enjoyed these areas was to be with friends and family or being connected with where they were born or where they grew up:

> My special place is Rotorua because it's home to me… I know a lot of people here and all my family's here so it means a lot. (AS1)

Both types of teachers considered their home, home town, homestead or their home country as special and other examples included areas in Rotorua or New Zealand. Teachers associated these areas with family, as well as other family-related explanations, such as it was their homestead, where they grew up, where they had whakapapa or genealogical links or where they spent family holidays.

An example of a whakapapa connection included:

> Ko te kāinga… Tipu ake, pakeke mai aku tungāne, tōku tuakana hoki ki reira. Nō reira, ko ngā maumaharatanga o te wāhi rā, he whenua nō tō mātou koroua. Nō reira, he hononga a whakapapa hoki ki te whenua
> (It is home… My siblings and I grew up there. From memory it is my grandfather's land. So there are genealogical connections to the land.) (TS5)

Both kaumātua viewed the central Ngāti Whakaue village of Ohinemutu as important because of family connections, as described by one elder:

> Koira te waahi tino pai ki au nā te mea te kāinga, taua kāinga nō te kuia o taku hoa tāne. Nāna i whāngai taku hoa tāne…
> (That is a special place to me because it was the home of my husband's grandmother. She raised my husband…) (K2)

This finding suggests that if science programmes were delivered in connection with the local context, then input from people with whom students have significant relationships beyond the school setting could be beneficial for student engagement. Some students may engage more if their background and those they care for were acknowledged as part of their learning. Students may engage more with teachers who share their significant places and relationships and allow opportunities to make personal connections to their teaching and learning of science.

The fact that all groups of participants had ideas about how the location of Rotorua could be included in school science is encouraging for the implementation of the local context principle. All groups of participants described a range of possible teaching topics and had a range of ideas about how they could be supported. However, participant responses suggested that they had experienced limited school science happening involving Rotorua. Further questions need to be explored to support the implementation of the local context principle which includes: "How do schools access and implement local indigenous knowledge applicable to their science programmes?" and "How do schools and their indigenous communities work together to deliver science programmes in local contexts to meet the needs of their students?"

5.7 Conclusion

Participant responses have provided some valuable insights, challenges, and questions in addressing the research question: “How do schools include Ngāti Whakaue in science education?” There was varied evidence of schools within the Ngāti Whakaue context recognising the place of Ngāti Whakaue in school education, as represented by Māori students’, senior science teachers’ and local kaumātua perceptions. The evidence was gathered and examined through the exploration of the six principles of a proposed indigenous community-based science programme. The key findings in relation to each principle are now summarised.

The partnership and power-sharing principle supports students, teachers, schools and indigenous communities, all being part of the decision making of what is included in science education programmes. Responses from all groups of participants suggested that they had experienced little or no inclusion of Māori knowledge in school science. However, all groups provided possible ideas as to how to include Māori content and teachers identified possible support. Teachers were possibly unsure how or were unwilling to connect with Māori communities and maybe also with their Māori students.

The shared values and aspirations principle supports that an indigenous worldview is included in science education programmes, including cultural perspectives about identity, knowledge, and language. All groups of participants had an understanding of Māori culture but had varied views and engagement with it. The marae or Māori central meeting place was viewed by students and local elders as the base location of Māori culture.

The culturally responsive pedagogy principle supports the interchange of teacher student roles in science education programmes as a means to understand each other's' cultural backgrounds and associated bodies of knowledge. All groups of participants provided a wide range of contexts for learning about science in their everyday lives but which was limited in the school setting. No examples of Māori contexts were given. All groups of participants stated their enjoyment of school science depended on the teacher. This was contradictory to students stating clear science career goals; however, teachers had limited knowledge of their students' future goals, therefore possibly limiting their ability to meet student needs. Kaumātua thought students should pursue careers to contribute to their people, which some students agreed with. Teachers and kaumātua advocated for learning school science outside of the classroom; however, most students saw school as the central location for learning school science.

The resourcing principle advocates schools accessing appropriate resources to ensure sufficient capacity, capability, implementation and monitoring support to include an indigenous perspective in science education programmes. These include people resources such as local indigenous elders and other local advisors with knowledge unique and relevant to the culture of a specific community. All groups of participants had ideas about how Ngāti Whakaue could be included in school science; however, some students and teachers had limited knowledge or engagement with Ngāti Whakaue.

The collaboration principle in practice supports collaborative processes and systems to ensure the implementation of both indigenous and science bodies of knowledge in science education programmes. There was minimal evidence of teachers working collaboratively with Māori communities. Story-telling was proposed as a collaborative pedagogical approach but possible tensions and issues exploring the validity of both knowledge systems in the science classroom were identified. Kaumātua again suggested the use of marae as the key location for teaching Māori science education.

The local context principle is the final principle of the indigenous community-based science programme argued in this thesis. This principle supports the inclusion of local phenomena, and local issues in science education to ensure positive engagement by indigenous students. All groups had knowledge of the Rotorua area, which they viewed as a rich learning location. All groups of participants connected their sense of belonging to a place with being with loved ones. Again, there was limited evidence of this principle in practice and some disconnect between students, teachers, and Māori communities.

In conclusion, the analysis of participant responses in regards to the research question has revealed the overall finding that there is limited evidence of the context of Ngāti Whakaue being recognised in science education in the Ngāti

Whakaue setting. There was also evidence that the proposed principles of an indigenous community-based science programme were being implemented to varying but limited degrees. These findings indicate that there is potential to implement this approach to indigenous science education and highlights possible tensions and issues that would need to be addressed to ensure successful implementation.

Three key themes were identified as possible reasons why there was limited evidence of the inclusion of the Ngāti Whakaue context in science education and implementation of the proposed principles. These themes are also positioned as possible enablers to improve the delivery of science programmes to engage Māori students.

1. **Importance of relationships.** Teacher–student relationships were identified by participants as being important for Māori student engagement (Section 5.3); however, there were examples of disconnect between students and teachers, between teachers and local Māori elders, and teachers and the local context (Sections 5.3, 5.4 & 5.6). In contrast, all groups of participants connected their sense of belonging and engagement to a place with being with loved ones (Section 5.6). These connections were not recognised strongly by participants in the school setting. These findings may suggest that science education that involves or acknowledges other important relationships and places in the students' lives may improve their engagement.

2. **Practical engagement with Māori content.** All groups of participants shared responses that suggested they had theoretical understanding of Māori knowledge (Sections 5.1, 5.5 & 5.6). Their recall of actual application in science classrooms suggested there were no clear processes about how to access or implement Māori content (Section 5.1 & 5.4). Findings suggest that actual involvement with Māori cultural activities by teachers may influence how Māori culture and knowledge are valued and in turn implemented in the science classroom (Sections 5.1, 5.2, 5.3, and 5.6).

3. **Education outside of the classroom.** Learning science outside of the classroom was favoured by teachers and local elders but not particularly by students (Section 5.3). The research context of Rotorua, and more specifically Ngāti Whakaue, was viewed as a rich learning environment by all participants, yet was not strongly evident in science programmes (Sections 5.3, 5.5 and 5.6). Marae were viewed as central locations for Māori cultural activities and knowledge by all participants (Sections 5.1, 5.2, 5.4, 5.5 and 5.6). Therefore, marae could be possible sites to collaboratively deliver science programmes.

The next chapter will provide a more critical discussion of these findings, key questions and themes, with support from literature and theoretical frameworks to further argue that indigenous community-based science programmes have the potential to engage indigenous students.

CHAPTER SIX – DISCUSSION

6.0 Introduction

This chapter will present a critical discussion of the research findings, key questions and themes identified in the previous findings chapter. This research set out to answer the question: "How do schools include Ngāti Whakaue in science education?" The proposed principles of an indigenous community-based science programme aimed at engaging indigenous students in science education were used as framework to investigate this research question.

The overall finding was that there was limited evidence of the proposed principles being recognised and implemented in science education in a Ngāti Whakaue setting. This finding limits possibilities in science education for students, teachers, and the Ngāti Whakaue community. However, three enabling themes were identified in Chapter Five that could possibly facilitate improved engagement with, and outcomes for science for Ngāti Whakaue and other indigenous communities. These themes were: the importance of good relationships between students, teachers, schools, and Māori communities; the inclusion of practical engagement with Māori content; and education outside of the classroom, engaging with authentic and unique Māori locations such as marae.

This chapter is divided into six sections that discuss and critique the research findings in relation to each proposed principle. Each section will also include a discussion about how the key themes could be implemented to enable the improvement of the inclusion of local Māori context in science education to engage Māori students. This discussion will make links to current research in applicable areas and, in parts, highlight how this thesis adds to research. This chapter will also provide a summary of limitations and recommendations about what the implementation of the principles of an indigenous community-based science programme could look like in a Ngāti Whakaue setting. In addition, there is a specific section dedicated to identifying this thesis' contribution to indigenous education. The conclusion section of this chapter will provide a synthesis of the research findings and recommendations in the form of a final framework and an example of a possible Ngāti Whakaue science education topic.

6.1 Partnerships and Power-sharing

The partnership and power-sharing principle in practice focuses on students, teachers, schools and indigenous communities all being part of the decision-making about what is included in science education programmes. A relationship has been identified between indigenous student positive engagement with school science and the autonomy to direct their own learning in partnership with their teachers (Woods-McConney et al, 2013). The partnership and power-sharing principle also relates to a Kaupapa Māori theory principle, tino rangatiratanga (G.H. Smith, 2003) that promotes teaching strategies and teacher attitudes and beliefs that allow partnership and power-sharing with Māori students and their communities (Bishop & Glynn, 1999). The New Zealand science curriculum has a history of having minimal inclusion of Māori knowledge content or perspectives (McKinley, 1995; 2005), which Stewart (2011) suggests could be improved if a more critical perspective of science was part of an approach to Kaupapa Māori science education. This may involve Māori communities, including Māori students, being involved in decision-making about curriculum content, pedagogy and delivery.

The overall key finding in this study in relation to the partnership and power-sharing principle was that each group of participants indicated that, from their recall of school science experiences, there was little or no inclusion of what they perceived as Māori knowledge. However, all groups provided ideas about possible ways to include Māori content and teachers identified possible support. A possible reason for such lack of inclusion may be that clear processes that could allow Māori students, teachers and their communities to support the inclusion of Māori content in their science programmes may not have been in place. Participant responses also indicated that the curriculum content and pedagogical decisions seemed primarily to have been made by the science teacher. Bishop et al. (2007) identified in their New Zealand-based study that students reported they engaged less with teachers who dominated the classroom by instructing and controlling students. In this same study, students shared that this approach to teaching allowed them limited input into their learning and opportunities for their prior knowledge to be recognised including their cultural background. Therefore, student engagement may be improved by, first, teachers allowing some autonomy and, second, teachers considering the inclusion of the cultural backgrounds of their students in their science teaching supported by working with their students' cultural communities.

McKinley et al. (2004) stated that partnerships between schools and Māori communities ensured that Māori knowledge is an integral part of their science learning and not an additive. This assertion suggests that teachers and schools need to identify and prioritise processes to engage with their Māori communities. This is supported by Bishop and Glynn (1999) who stated schools that engage in partnership and power-sharing strategies and practices with students and the local community have had positive results for indigenous students.

Some English-medium teachers in this study were possibly unsure how or were unwilling to connect with Māori communities and also with their Māori students. Evidence of not knowing how was when some English medium teachers shared that possible inclusion of Māori content or perspectives was about exploring race and ethnicity, through deficit-focused topics like high rates of Māori obesity and diabetes (Section 5.1.1, para.6). Evidence of unwillingness to include Māori content in science education was shown by teachers from the same school, who viewed this approach as potentially promoting racial profiling and segregation (Section 5.1.1, para.8). These perceptions could be viewed as an excuse not to include Māori content or perspectives in their science learning or just not knowing how or not knowing where to find support. Either way, teachers should be aware of implications associated with using examples about particular races and ethnicities before teaching, as part of a context with students. Sharing of deficit information, stereotypes and personal perceptions, as one teacher did with sharing statistics about high rates of obesity and diabetes for Māori, may cause negative engagement from indigenous students.

Another risk is that all students could interpret poorly researched information and teacher perceptions as fact.

Others appeared more willing to include examples of Māori knowledge and culture in their science teaching but spoke about their lack of confidence in their understanding of such aspects. Māori medium teachers also struggled with how to include a Māori perspective in science as some shared their concern of having limited science content knowledge. In Wood and Lewthwaite's (2008) study of Māori medium science classrooms, parents and wider family members were involved in the planning and content of their children's science learning, aimed at providing both science and Māori knowledge. This is an example of schools accessing support systems for teachers, which should be considered if the implementation of the partnership and power-sharing principle is to be implemented more effectively.

Questions were raised in the previous chapter regarding possible solutions to the barriers identified by teachers in implementing Māori content in their science programmes. There were also questions as to who should initiate, implement and manage these solutions and the nature of partnership and power-sharing practices that could support these possible solutions. The three enabling themes identified in the findings chapter may offer some answers, as is discussed below.

The first enabling theme was identified from evidence that all groups of participants identified that teacher–student relationships were important for student engagement with science education. In their study about science teacher engagement with Māori students and concepts, Glynn et al. (2010) identified some successful strategies that involved positive teacher–student relationships. One teacher in their study described how they promoted partnerships with their students by requesting assistance in the preparation of a field trip and asking students what content they wanted to explore in relation to Māori culture. Place-based theorist Greg Smith (2002) suggested a strategy where teachers empowered students to lead the direction of investigations while teachers provided resources and made links to school requirements such as assessment of learning. Kawagley et al. (2010) agreed that it was important for indigenous student engagement when teachers allowed students to direct science investigations in a local setting. Place-based education pedagogy offers the inclusion of reflective learning strategies (Meichtry & Smith, 2007) such as regular group discussions and review of programmes with students and community to ensure shared input in classroom teaching. This study builds on these ideas by suggesting that science education programmes that acknowledge and include important relationships with people **and** places, in Māori students' lives beyond the classroom, may improve their engagement.

The second enabling theme was identified from evidence that all groups of participants had an understanding of Māori knowledge but the few teachers who included Māori content in their science teaching were those actively involved in Māori culture. The few examples of English-medium teachers who involved themselves with Māori cultural activities were initiated by each teacher on their own accord because of their desire to make a connection with their

Māori students. Most examples were school-based interactions, including one teacher who observed a school kapa haka performance and one teacher who incorporated one student's knowledge and interest in Māori knowledge of medicinal plants in their science teaching. One teacher became involved in Māori activities outside of school due to a student showing appreciation for the teacher's support for them by inviting them to family functions at local marae. These teachers were proactive in engaging with their students' cultural background by involving themselves in Māori cultural activities and could potentially encourage their colleagues to take the same initiative.

A next step for these teachers could be to make connections with their Māori students' communities through the positive relationships they have built with their Māori students. Brayboy and Castagno (2008) have similar views that it is not the role of the school to teach the indigenous culture or language of the local community; however, it is the role of teachers, curricula and schools to develop and maintain an intimate relationship to access support for their Māori students. The examples of teachers involving themselves with Māori activities in this research were not deliberately planned and the benefits for teachers and their Māori students were a revelation for these teachers. This thesis suggests that there may need to be more formal processes in place to improve science teacher involvement with Māori cultural activities through their Māori students and their Māori communities. In a set of guidelines intended for iwi and science organisations, Cram (2002) offered some key tasks for groups to consider when working with Māori communities about science topics. One task that Cram (2002) suggested was that outside groups and iwi needed to be clear about what the purpose and intended outcomes of the partnership would be. These guidelines could be applicable to teachers and schools whose purpose is to be involved with iwi activities as a means to better engage their Māori students in science education. Cram (2002) also recommended that iwi and science groups formalise agreements and share analysis, evaluation and dissemination methods used to monitor progress in achieving shared goals.

The third and final key enabler identified in this research offers a location for these types of partnership and power-sharing practices where teachers could authentically take part in Māori cultural activities. Marae were viewed as central sites of Māori cultural activities by all groups of participants, so therefore could be possible sites for teachers and local iwi to work together to deliver science programmes. Aikenhead (2001) described projects where power-sharing and life-long learning were modelled when students and teachers both learnt from local indigenous elders who shared their knowledge about a specific science topic in local indigenous settings. Local elders and other members of the local community with specialised knowledge were seen as teachers also and outside indigenous environments as places of teaching and learning. Kawagley et al. (2010) in their work with indigenous communities reported that local indigenous elders wanted their children to be provided science programmes that included a wide range of learning experiences delivered in partnership with schools and indigenous communities. For these strategies to be implemented there would need to be some indication of shared values and aspirations between schools and indigenous communities. This is discussed further in the following section.

6.2 Shared Values and Aspirations

The shared values and aspirations principle promotes the inclusion of an indigenous worldview in science education programmes, including cultural perspectives about identity, knowledge and language. Chapter Two outlined how this thesis defines Māori culture and acknowledged that diverse definitions exist, for example Durie (1995) includes aspects of identity and wellbeing, May (1998) adds language, and Bishop and Glynn (2000) incorporate language and knowledge. This thesis defines Māori culture as perceptions of identity, knowledge and language. Identity encompasses views and beliefs about how groups of Māori relate to the world around them. Knowledge describes what Māori observe, interpret and know about the world. Māori language is the vehicle to communicate shared views, beliefs, observations and perspectives.

Barnhardt (2005) stated that the inclusion of cultural core values was an important component of education initiatives and having an understanding of the values of your own culture and other cultures' values allows all students the opportunity to engage, interact and critique a wide range of knowledge systems. Brayboy and Castagno (2008) agree that the epistemological and socio-cultural views of an indigenous community need to be acknowledged and included in a successful indigenous science programme. Indigenous science education commentators argue that having an understanding of the students' indigenous language supports understanding of local cultural practices and knowledge and contributes to addressing the issue of minimal indigenous content in science classrooms (Aikenhead, 1997; McKinley, 2001). This principle is similar to

Graham Smith's (2003) taonga tuku iho principle that asserts being Māori is both valid and legitimate, including the Māori language, culture and knowledge. Stewart (2011) also views an awareness of the importance of Māori philosophy, principles and practices, including language and culture as an important characteristic of Kaupapa Māori science education.

The overall finding in relation to the shared values and aspirations principle was that all groups of participants had an understanding of Māori culture but had varied views about Māori culture and varied levels of engagement with it. Glynn et al.'s (2010) study described how a teacher became more aware of the privileged position of science knowledge compared to Māori knowledge and, when preparing a unit, researched Māori and science worldviews about environmental ecology and sustainability. As a strategy to acknowledge a balance of worldviews, all teachers in Glynn et al.'s study worked toward ensuring that local Māori knowledge was respected at all learning sites, in and out of the classroom.

A key concern from the findings in this thesis was that English medium teachers' actual involvement with Māori cultural activities was either minimal or non-existent. A possible reason why English medium teachers were not involved in Māori cultural activities may have been because of a lack of connection with Māori cultural environments such as local marae. Marae were viewed by students and local elders as the base location of Māori culture. The lack of engagement displayed by English-medium teachers could be due to not having the opportunity to visit marae or being willing to engage with local Māori communities but again not knowing how to.

Questions raised by the findings included: “How do schools support their teachers and students to practically engage with Māori culture?” and if marae form a place for this engagement to happen: “How do schools connect with local marae?” The second enabling theme identified from the findings (Section 5.7) offers possible solutions to these questions, and suggests that practical engagement with Māori culture may promote stronger awareness of a Māori worldview and its inclusion in science teaching. An essential part of learning about Māori culture is learning te reo Māori and tikanga Māori or Māori language and protocol (Bishop & Glynn, 2000; Durie, 1995; 1998; May, 1998; Walker, 1990). The final enabler offered in this research promotes education outside of the classroom as supporting Māori student engagement with science education (Section 5.7). Specifically, the use of marae as possible sites to collaboratively deliver science programmes. Marae are the key source of Māori cultural practices including the Māori language and protocol (Berryman & Bateman, 2008; Macfarlane, 2004; Macfarlane et al., 2008; Mead, 2003; Walker, 1990).

As stated in Chapter Two (Section 2.1.3), Māori language was a fundamental element of Māori culture (Penetito, 2010). The decline in the use of te reo by Māori began post Treaty of Waitangi (Walker, 1990) and continued into the 1970s, until revitalisation began, predominantly in schooling (Durie, 1998; Walker, 1990). Māori leader Sir James Henare viewed Māori language as the foundation of Māori culture and the essence of Māori existence (Waitangi Tribunal, 1989). Therefore, this thesis asserts that Māori language is an essential element of Māori culture; a unique indicator of Māori identity and the critical vehicle in the transferring of Māori knowledge.

The use of indigenous languages in the science classroom encourages students and teachers to explore different perspectives due to the varied structures of languages representing different worldviews (Metallic & Seiler, 2009). A common response from students was that being Māori gave them a sense of identity and one of the unique indicators was the Māori language. The other common unique activity that students shared was kapa haka or Māori performing arts, which are also conducted in the medium of the Māori language. Most secondary schools in New Zealand have a Māori language programme where they work towards credits for the national secondary school qualification. Most schools also have a competitive kapa haka group offered as an extra-curricular activity for all students and some compete in regional and national secondary school competitions. Some schools offer programmes where kapa haka is part of the curriculum and students can earn qualification credits in performing arts or the Māori language.

Science teachers could involve themselves in these school-based examples of Māori activities to improve their practical engagement with Māori culture. Involvement may begin with observations of their colleagues' Māori language classrooms or kapa haka practices and performance and then progress to participating in them if their school progamme allows. Involvement in these

Māori-focused programmes could support science teachers to make connections to local marae through engaging with their colleagues and students who participate in them. If schools encouraged this type of participation, teachers and students would have more than just an understanding of local cultural practices and knowledge; they would be highly engaged with Māori culture (Aikenhead, 1997, 2001; McKinley, 2001; Bishop & Glynn, 1999; Waiti & Hipkins, 2002).

Teachers from both types of schools explored in this thesis could benefit from working with local Māori communities to improve their inclusion of the Māori language, protocol and content knowledge in their science programmes. The importance of relationships between schools, teachers, students and the students' communities has been identified in this thesis as a key enabler for positive Māori student engagement in science education (Section 5.7). The establishment and maintenance of relationships would involve practices of acknowledgement, care, consultations and mutual respect by both parties. Kawagley (2000) stated that the acknowledgement of indigenous languages was a fundamental approach to recognising the unique contribution that indigenous cultures have to offer schools. In regard to an indigenous language being included in the delivery of the science curriculum, care and consultation with local experts was vital to ensure appropriate use of terminology, as well as respect and understanding of the local context. Translations of an indigenous term into another language may obscure or misinterpret the actual meaning and understanding for students and teachers if appropriate consultation or care is not taken (Aikenhead, 2001).

Findings in this research have identified the inclusion of education outside of the classroom, specifically in unique Māori cultural locations, such as marae, as an important enabler for Māori students to engage positively with science education. Connection with marae, would also involve connecting with Māori language, protocol, history and knowledge, through connecting with local Māori. The implementation of the enablers identified in this research may involve culturally responsive pedagogy strategies discussed in the following section.

6.3 Culturally Responsive Pedagogy

The culturally responsive pedagogy principle acknowledges the interchange of teacher–student roles in science education programmes as a means to understand each other's cultural backgrounds and associated bodies of knowledge. This principle is similar to a Kaupapa Māori theory principle defined by Graham Smith (2003) as 'ako' or the interchange of roles between teacher and student where each can learn and be taught by the other. This principle also recognises both indigenous and science knowledge as equally valid in the science classroom and is similar to one of Stewart's (2011) characteristics of Kaupapa Māori education where the validity of science knowledge found within mātauranga Māori is important and valued in science teaching and learning.

The dominant culture of many science classrooms is viewed as Eurocentric (Aikenhead, 2011; Cowie et al, 2011), based on Western science principles that are sometimes in opposition to indigenous scientific views (Abrams et al, 2013). In practice, the culturally responsive pedagogy principle would involve indigenous student and teacher prior knowledge, backgrounds and perspectives being included in science teaching and learning. Abrams et al. identified that one of the main reasons why indigenous students disengage with science education is the lack of content or pedagogy that reflects their culture. Curriculum content and pedagogy that make connections with the learner's culture (Bishop & Glynn, 1999) have been promoted as a way to engage indigenous students with science education (McKinley, 2005).

One key finding in relation to this principle was that all groups of participants provided a wide range of contexts where they perceived they had learnt about science and where science learning could occur in their everyday life outside of the school setting. The most common example of a specific context shared by all groups of participants was geothermal activity in the Rotorua area. However, the range of contexts was limited when participants shared their experiences of teaching and learning school science. Metallic and Seiler (2009) stated that science classrooms where teachers and students are able to equally share their stories and experiences in relation to a science concept or topic support students to connect easily with the learning. Therefore, this finding indicates that there is room for improvement in the area of teachers and students having opportunities to share their lived experiences and perceptions of science outside of the classroom with each other. This finding was also one of the main contributors to the identification of the third key enabling theme of this research (Section 5.7) that promotes the inclusion of science learning experiences outside of the classroom to support the positive engagement of Māori students with science education.

The need for increased learning experiences outside of the classroom is further supported by the fact that, of the three groups of participants, students had the most limited perception and experience of science and most examples were activities based in the school setting. One reason why some students had this view may be that, as young people, school was the main focus of their immediate lives. Other reasons could be because they perceived science as only a subject taught in the classroom environment, or that they disconnected what they learnt at school from their perceived science experiences outside of school because of how their science programmes were being delivered. Exploring the local culture, history and experiences of indigenous students' families and local communities in their own settings would allow for indigenous knowledge to be seen as a valid part of science programmes and for students to connect school science with their lives beyond the classroom (G.A. Smith, 2002). The fact that all groups of participants shared that they enjoyed learning experiences outside of the classroom and included activities involving the local environment is encouraging for the implementation of the culturally responsive pedagogy principle.

All groups of participants shared that their enjoyment of school science depended on the influence of their science teachers. This finding was the main contributor to the identification of the first key enabling theme (Section 5.7) that supports the need for quality teacher–student relationships to enable positive Māori student engagement with science education. The relationship between Māori students and teachers was a concern in this study as some teachers could not identify who their Māori students were.

Another area of concern in regard to teachers in this study was that they had mixed knowledge and understanding of their Māori students' science aspirations. One stark finding was that some English medium teachers did not know which of their students were Māori. This finding is contradictory to the culturally responsive pedagogy principle which promotes teachers having a good understanding of their students' needs and interests, especially when teachers themselves shared that the role of the teacher was an important part of student engagement with school science. Sutherland and Swayze (2012) agreed that the success of how well teachers included indigenous knowledge into their science teaching was dependent on their relationships with their indigenous students. Indigenous students often interpret ideas about the world around them from their cultural background perspective. A student's indigenous worldview needs to be considered in the science classroom, as sometimes what could be interpreted by a teacher as a student having a lack of understanding of a concept is actually a student having a different perspective. A student may disagree with the interpretation of a concept being taught in the science classroom and disengage with the learning (Snively & Corsiglia, 2001). Aikenhead (1997) professes that many science classrooms are a subculture and location of Western science, where the indigenous cultures of their students are rarely recognised or located. This suggests that in their science teaching, if teachers are to first acknowledge then learn about their students' indigenous knowledge and experiences, they may need to access this support from outside of the school setting.

Penetito (2009) agreed that in place-based education programmes it is the role of the teacher to include an understanding of their students' backgrounds, content and pedagogical knowledge. New Zealand-based research and secondary school professional development programmes focused on Māori student outcomes revealed that teacher relationships with students supported improvement in this area (Bishop, 2006; Bishop et al., 2006; 2007; 2009; Tuuta et al., 2004). These projects examined what culturally responsive pedagogy could look like in regard to relationships between teachers and Māori students and identified the Māori concept of ako or reciprocal teaching and learning as a fundamental approach to promoting effective teaching and learning (Bishop, 2006; Bishop et al., 2006; 2007; 2009; Tuuta et al., 2004).

Local kaumātua and other outside agencies, such as science organisations, could be potential support systems for teachers for relationship-building and implementing practical experiences exploring Rotorua that some schools had partly included in their science programmes. A more structured approach to implementing the culturally responsive pedagogy principle may also support teachers. Aikenhead (2001) argues that the development of an indigenous knowledge framework for science programmes is a successful strategy to support science teachers in building relationships with their indigenous students. The guidelines would provide clear understandings from indigenous and Western science knowledge systems. Aikenhead (2001) states that for successful integration of Western science knowledge and indigenous knowledge in cross-cultural science learning, units needed to clearly outline the local indigenous knowledge and the Western science knowledge as two worldviews or perspectives (Snively & Corsiglia, 2001). The focus would be on student understanding, but not to the detriment of one knowledge system being assimilated into the other, or for the student to wholly adopt either worldview (Aikenhead, 2001). Glynn et al.'s (2010) study described how one teacher supported their students with accessing a range of resources when researching Māori and science worldviews about environmental ecology and sustainability. Issues related to accessing resources will be discussed in the following section.

6.4 Resources

The resourcing principle of an indigenous community-based science programme advocates accessing appropriate resources to ensure sufficient capacity, capability, implementation and monitoring support to include an indigenous perspective in science education programmes. In practice, the inclusion of local indigenous elders and other local advisors with knowledge unique and relevant to the culture of a specific community would be a vital component of science education. Local physical resources and environment would also be important, as well as local practices that preserve these areas. This principle is similar to Graham Smith's (2003) Kaupapa Māori theory principle 'kia piki ake i ngā raruraru o te kāinga' defined as practices and values that work to ensure that a collective responsibility will come to the foreground in order to ensure the overall wellbeing of the community. In her Kaupapa Māori science education characteristics Stewart (2011) campaigns for political legitimacy and entitlement to state resources as mandated by the Treaty of Waitangi to allow the freedom to develop Māori science education from a Māori worldview.

Participants were asked their perceptions of Ngāti Whakaue to establish to what extent the local context of the research setting was included and utilised in the local setting. The resourcing principle was evident to some extent, as all groups of participants had ideas about how Ngāti Whakaue could be included in school science. However, all groups of participants had limited or no school science experiences about, within, or including a Ngāti Whakaue context. Kaumātua were the one group that had strong knowledge and engagement with Ngāti Whakaue. Participants identified some possible resources and processes that could support schools to include Ngāti Whakaue in their science programmes. These included local kaumātua, historians, marae, and local government councils. The importance of relationships was the first key theme identified in the research findings (Section 5.7), and could be an essential enabler to ensure access to a range of resources, especially people. Sufficient funding from a range of sources to support students, teachers, schools, and local indigenous communities has been identified as an important component of indigenous community-based science programmes (Aikenhead, 2001; Barnhardt & Kawagley, 2005).

The Alaska Rural Systemic Initiative is an example of a national programme where sufficient funding was essential to fund vital components of the approach to indigenous science education (Barnhardt & Kawagley, 2005). These included communication tools, such as newsletters, websites and regular regional meetings, which were used to disseminate the latest information, developments and materials. A national coalition of science-focused providers collated professional development and curriculum resources and regional associations managed implementation and on-going development of the initiative and pedagogical practices. The enabling theme of the importance of relationships is evident in this example of an indigenous community-based science programme. Effective relationships between the local setting, science-focused outside agencies, schools, teachers, and students would, again, be an essential enabler for these examples of communication processes and support systems to be implemented and managed.

Despite there being limited evidence of Ngāti Whakaue being experienced by participants in their science teaching and learning, some participants had knowledge of Ngāti Whakaue ancestry, genealogy, stories, and history. The second enabling theme of practical engagement with Māori culture (Section 5.7) was not evident; however, the fact that some participants had some knowledge of Ngāti Whakaue indicates potential for practical activities associated with this knowledge to be implemented in science classrooms. A possible source of this knowledge could be local Ngāti Whakaue kaumātua. As stated earlier, both kaumātua participants were knowledgeable and engaged regularly with activities in the Ngāti Whakaue setting. Glynn et al. (2010) agreed that local Māori elders and members of the wider Māori community were valuable resources who offered knowledge about local stories and flora and fauna. Teachers also accessed other resources, such as local conservation workers and specialised science laboratories, which was viewed as an important resource for science teaching and learning. Lee et al. (2012) reported that many indigenous communities' depositories of local indigenous knowledge and skills about the natural environment risk being lost if local knowledge is not taught to or engaged with by local students. G.A. Smith's (2002) place-based theory approach promotes the community where students have grown up as a viable resource and opportunity for their vocational future. Sutherland and Swayze (2012) provided a school-wide example where teachers had the autonomy to access resources including local elders; however, finding local elders who had both an understanding of cultural and scientific knowledge was difficult. This would be a very common situation in many Māori communities so accessing support resources from a range of science-focused groups and organisations could be a viable option to have a balance of cultural and scientific knowledge included in science programmes.

Limited access to resources is of particular concern at the senior science level in Māori medium science classrooms, due to limited teacher capability with specialised science and Māori knowledge, as well as being fluent in the Māori language (McKinley et al., 2004). Wood and Lewthwaite (2008) offered a solution where fluent Māori-language-speaking teachers with both Māori and science knowledge were rotated around the school to support less knowledgeable teachers and their students. This is an innovative example of using accessible resources. There was evidence of both Māori medium schools accessing outside agencies to support their science programmes either due to limited teacher capability or the need for specialised skills and knowledge. One school used the national correspondence school and one had used tertiary-level experts. Māori medium classrooms could also be supported by local kaumātua, despite there not being any evidence of this happening as shown in all groups of participants' responses.

The final enabling theme of the importance of including education outside of the classroom in science programmes was evident in the research findings. All groups of participants shared possible outside learning experiences, including engaging with the local physical environment, exploring local issues and engaging with local Māori culture. Substantial funding could allow the production of teaching units for sharing throughout a local community and all parts of the community could help provide capacity, capability, implementation and monitoring support. Ngāti Whakaue currently funds education initiatives and organisations at all levels predominantly through the Ngāti Whakaue Education Endowment Trust Board (Ngāti Whakaue Education Endowment Trust Board, 2012; 2103). The majority at primary and secondary school level are literacy and numeracy focused, aside from one adventure academy project for middle school students and a Māori teacher aid role in a secondary school.

Ngāti Whakaue also provides a range of grants and sponsorships for individuals and groups to support Ngāti Whakaue membership with achieving their education goals as well as contributing to iwi goals (Ngāti Whakaue Education Endowment Trust Board, 2012; 2013). A recent initiative by the Te Taumata o Ngāti Whakaue Iho Ake education initiative arm of the Ngāti Whakaue Education Board is the establishment of two education leadership positions. One position is for a tribal curriculum and professional learning development advisor whose role would be to provide learning materials to schools that reflect Ngāti Whakaue identity, language and culture. The other position would be to provide science and technology experiences for young people aged 7–14 outside of school that also reflect Ngāti Whakaue. This is an example of a possible collaborative process that could connect schools with their local iwi. Other collaborative possibilities will be discussed in the following section.

6.5 Collaboration

The collaboration principle promotes collaborative processes and systems to ensure the implementation of both indigenous and science bodies of knowledge in science education programmes. In practice, this principle would involve students, schools, teachers and Māori communities working together in the delivery of science programmes that included both Western and Māori perspectives. This principle is similar to G.H. Smith's (2003) Kaupapa Māori theory 'whānau' principle, which represents cultural practices, values and customs organised around whānau and collective responsibility that ensure Māori wellbeing, and educational achievement. Stewart (2011) also valued collaboration, with one of her Kaupapa Māori science education characteristics promoting the importance of cultural interdependence of science processes and science as a cultural knowledge product.

In their science education initiative aimed at including both Western and indigenous knowledge in schools, Barnhardt and Kawagley (2004) stated that it was vital to have an inclusive management framework containing comprehensive systems, which contributed to affirmative reciprocal partnerships for all involved. Participants were asked about how Māori knowledge could be included in science education with the support of collaborative practices. The overall finding in relation to the collaboration principle was that all groups of participants were able to give further examples of possible science teaching and learning activities involving Māori knowledge that could be included in science programmes. Similar to findings discussed in previous sections of this chapter, there was minimal evidence of teachers including Māori knowledge in their science programmes or working collaboratively with Māori communities. Kaumatua again suggested marae as possible collaborative locations for science education to occur. Questions identified for further discussion if schools chose to work alongside Māori communities to implement their science programmes include: “Who initiates, develops, manages and reviews collaborative practices between schools and Māori communities?” and “Who manages the balance between the delivery of Māori and Western science perspectives?”

The building of collaborative relationships between Māori communities and schools is a priority in New Zealand as stated by the Ministry of Education (2009) in *Ka Hikitia – Managing for Success: The Māori Education Strategy 2008 – 2012* who were focused on:

> …increasing the confidence of people to work with Māori, and their capability to effectively deliver for and with Māori students, whānau, iwi and communities. (p. 3)

Glynn et al. (2010) reported that the building of collaborative relationships between Māori communities and schools aimed at including Māori perspectives into science teaching first involved teachers working with their students to engage with their immediate whānau. Wood and Lewthwaite (2008) also reported in their research with Māori medium science classrooms that input from parents and the wider Māori community was very important and actively sought by some schools. This strategy had students asking their parents about any local knowledge they had about particular topics, which then grew to working with wider whānau members. In their study, Glynn et al., (2010) stated that collaborative approaches were initiated by teachers with the primary focus being to include a Māori perspective in their science teaching; however, another outcome that teachers reported was the building of trusting and respectful relationships with their students. These examples of research in the area of Māori science education reflect the first overall enabling theme of this current research, which is the importance of quality relationships between teachers, students, and Māori communities.

Only one Māori medium teacher gave an actual example of a collaborative science learning experience that involved students, teachers, the wider school community, and science experts, and was based out in the local community. A vital part of these types of collaborative relationships is that teachers are working alongside their students to access knowledge and at times letting students take the lead in directing the learning (Sutherland & Swayze, 2012). Lee et al. (2012) provided further support for this strategy in also allowing students to choose whether they focus on a Western or indigenous perspective of their science learning to best fit their goals. In Wood and Lewthwaite's (2008) study, parents and wider family members were all included in the planning and content of their children's science learning. The focus was on providing a balanced view of science and Māori knowledge in the science classroom where the Māori worldview was the foundation, and that the science perspective supported student understanding.

Stephens (2000) advocated that thoughtful consideration of possible connections between indigenous and science knowledge systems may reveal some common ground in the form of principles, values, skills, processes and content knowledge. The main purpose of identifying examples of common ground is for educators with knowledge of either knowledge system to access the other. Providing access may be a possible solution to what Stewart (2012) acknowledges as a tension in Māori medium science settings between prioritising Māori 'cultural restoration' (p.60) through Māori language acquisition at the expense of mastering science knowledge and terminology. Stewart (2012) encourages Māori medium educators to reflect and critique their philosophical, cultural and educational priorities in regards to Māori and science education. The marae setting may be a collaborative location for these tensions to be explored by science educators.

The second overall enabling theme identified in this thesis is the inclusion of practical engagement with Māori culture as a key enabler for engaging Māori students with science education (Section 5.7). There was minimal evidence in this research of teachers including aspects of Māori culture in their science programmes. McRae and Taiwhati (2011) offered a collaborative practice framework modelled on the implementation of Māori concepts involved in the Māori cultural practice of pōwhiri. This framework was developed to support teacher educators with engaging schools and their Māori communities. Each stage of the framework provides teacher educators with examples of practice, questions to consider and proposed outcomes to support them. For example, the first stage is linked to the wero or challenge part of the pōwhiri process, as well the concepts of kaupapa and kotahitanga, to signify the initial task of teachers or schools to make contact with Māori communities (McRae & Taiwhati, 2011). The aim of this stage is to establish a foundation for a shared working relationship between teachers, schools, and their Māori community to achieve a common goal. Kaumātua saw marae as possible locations for science education and they could also be base locations for collaborative relationships to be established and maintained. This possible strategy aligns with the third overall key theme of including education outside of the classroom to engage Māori students, specifically activities based with local marae (Section 5.7). The utilisation of local resources, including marae, will be discussed further in the following section.

6.6 Local Context

The local context principle promotes the inclusion of local phenomena, including local indigenous communities and associated local issues, in science education programmes. Indigenous knowledge of the local natural world has recently been included in scientific studies based in Alaskan communities and explored as fundamental for school science programmes (Kawagley et al., 2010). G.H. Smith's (2003) Kaupapa Māori theory principle of 'kaupapa' is reflected in this principle as the content of the curriculum would be decided by the collective, including Māori communities, to achieve a common vision for Māori students in science education. This principle also aligns with one of Stewart's (2011) characteristics of Kaupapa Māori Science Education that values Māori community input into all aspects of pūtaiao or science curriculum.

The overall findings in relation to the local context showed that all groups of participants had knowledge of Rotorua and there was some evidence of local issues and topics included in science programmes. This finding shows that there is potential for the participants' local knowledge and connections with Rotorua, more specifically Ngāti Whakaue, to be included as a learning context in local school science programmes. Aikenhead (2001) stated that successful cross-cultural science programmes that incorporated the indigenous context of their immediate local community allowed opportunities for indigenous students to share knowledge associated with their own communities. Barnhardt (2005) identified that pedagogy associated with place allows indigenous students to be taught through their culture and immediate location as a means to connect with broader environments.

The local context principle was also evident in the finding that all groups of participants associated connecting or belonging to a place with spending time with family and friends. This finding suggests that if science programmes are delivered in connection with the local community, then it is vital to include input from people who students have significant relationships with beyond the school setting. This finding connects to the first overall enabling theme of the importance of relationships to support Māori students' positive engagement with science education (Section 5.7). Kawagley et al. (2010) also proposed that student engagement may improve when teachers combine their own science skills and knowledge and local elders for indigenous perspectives in their science programmes. As stated in earlier sections of this chapter, students may be the key point of access for teachers and schools to engage with local elders because of the students' already established relationships with them.

Place-based education theorist Gregory Smith (2002) stated:

> …that valuable knowledge for most children is knowledge that is directly related to their own social reality, knowledge that will allow them to engage in activities that are of service to and valued by those they love and respect. (p. 585)

G.A. Smith (2002) argues that many schools operate a curriculum that is classroom-based with lectures and texts about others' experiences with phenomena, asking students to master the knowledge of others that is disconnected from the rich learning experiences of their immediate location. G.A. Smith also stated that learning associated with a student's reality or location is more engaging for them through concrete experiences and gives them confidence to learn about more abstract ideas. All groups of participants recognised Rotorua as a rich learning environment and provided a wide range of locations; including geothermal, historical, and cultural that they thought were also important places. Some participants had experienced science learning in these places, which provides evidence that the local context principle was implemented to a certain extent; however, there was evidence that this was not common practice. The implementation of the local context principle could be improved if the third enabling theme identified in this thesis of including education outside of the classroom, more specifically, the inclusion of marae as learning locations (Section 5.7), was part of science programmes.

A place-based education approach to science programmes also provides indigenous students the opportunity to contribute to their immediate environment. Kawagley et al. (2010) agreed indigenous knowledge and practices in relation to the natural world are best preserved if students learn about them in authentic settings. Gruenewald (2003b) added that teaching and learning associated with the local context of a school engaged students and teachers more intimately with local issues and encouraged responsibility and accountability. Meichtry & Smith (2007) proposed that an effective place-based teaching strategy was the inclusion of the local environment as the basis of exploring local issues that students may be interested in. Some students spoke about wanting to contribute and make a difference for their Māori communities and for their immediate environment; however they felt that these opportunities were not offered in their science learning. Both kaumātua agreed that an important part of Māori students' science education was to make a difference for their Māori communities. Both students and kaumātua did not offer possible solutions about how science programmes could be improved to allow students opportunities to make a contribution to their immediate communities.

Again, the third enabling theme of including education outside of the classroom, specifically local marae as science learning sites could support students with contributing to their local environments. G.A. Smith (2002) reported positive outcomes including improved school achievement, specifically scientific understanding and problem-solving abilities from a school that placed natural local phenomena at the centre of their curriculum to meet the needs of their students and community. The process of setting up this place-based education approach involved school management working with like-minded parents, teachers and community members to access resources to shape a shared curriculum.

The above are helpful examples to consider for the implementation of local context principle and evoke the question: "How do schools access and implement local context applicable to their science programmes?" One possible strategy to address issues in relation to this question appeared in the findings. Access to local context was evident through participants' practical experiences at marae, museums and through visiting local historical and environmental areas. Schools could consider including such experiences into their science programmes. These possible strategies link to the second and third overall key themes of the current research, which first promote practical engagement with Māori culture. Second, all of these suggestions engage with education outside of the classroom. All groups of participants also had knowledge of local stories and history through formal education, family members, local experts or experiences out in the community. The sharing of indigenous stories and narratives that are connected to a specific location is a possible strategy to implement the local context component of an indigenous community-based science programme.

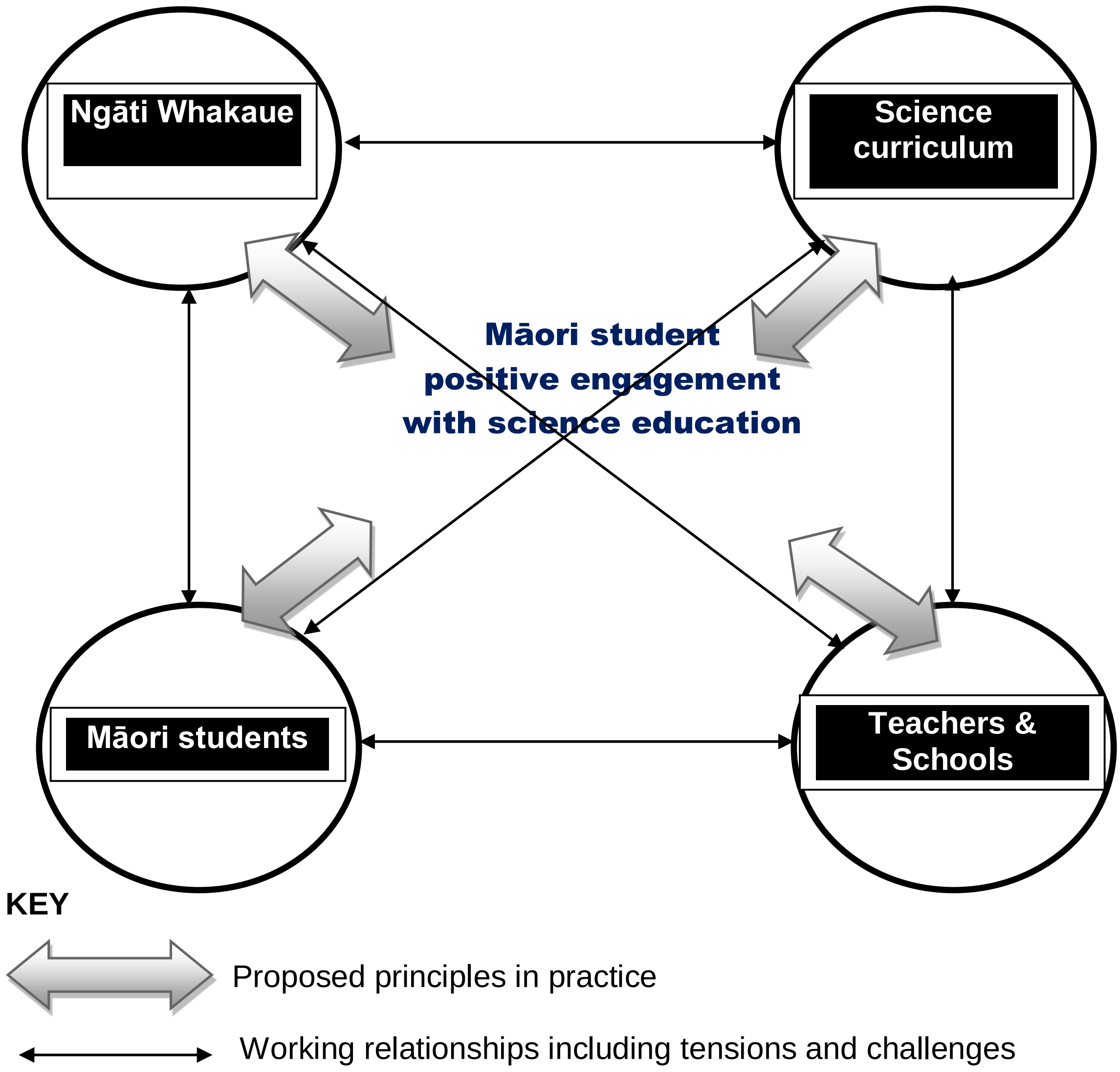
Narratives that connect land to people are a common practice for indigenous people that provide a source of knowledge and identity (Whitt et al, 2003). Māori traditional oral practices include the sharing of whakapapa and pēpeha that describe the holistic connection that many Māori have with the physical environment (Ministry of Education, 1992). Penetito (2009) saw elements of Māori philosophy and pedagogy in place-based education including whakapapa. This is supported by Carter (2005) who argues that every part of the physical and spiritual world has a whakapapa and is interconnected. Many Māori view themselves as being intimately connected with the physical environment and have strong kinship ties to their geographical boundaries. The oral introduction practice of pēpeha describes the relationship many Māori have with their physical environment and is a way of sharing knowledge about important locations to maintain and sustain the important reciprocal relationship between the environment and people (Carter, 2005). Glynn et al. (2010) observed an English medium science programme where a focus was for students to learn local Māori stories and history to explore different perspectives of scientific topics. With this type of approach teachers would need to research appropriate local stories to share with their students in their science classroom, which could only happen in consultation with local Māori.

As stated earlier, the first point of access for teachers could be through their students, who in turn could access their local Māori community. Again, the enabling theme of the importance of relationships would need to be a part of this process. The following example describes some risks involved if teachers do not have positive relationships with their students which could limit their understanding of their students' backgrounds. McKinley et al.'s (2004) project in a Māori medium school reported that a parent disagreed with local Māori knowledge being taught alongside science knowledge. The parent's opinion was that because their child was not from the local Māori area associated with the school, it was the role of their own Māori community to teach their children their knowledge. This highlights the importance of schools knowing the diverse backgrounds of their Māori families that could exist within their Māori communities and having strategies to ensure all diverse views about Māori content and curriculum delivery are considered.

6.7 Research Synthesis

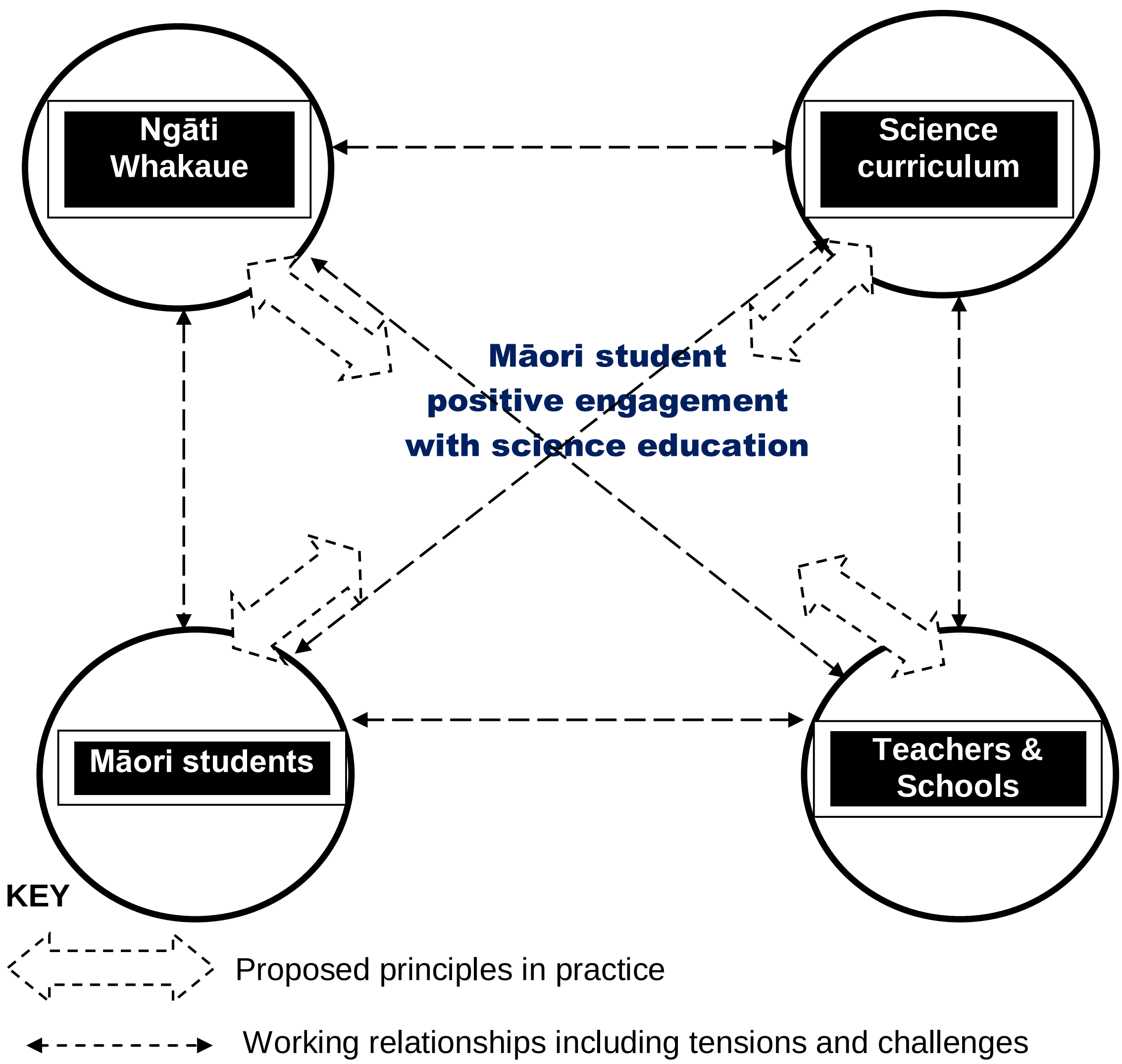
The overall aim of this research was to identify whether the proposed set of principles of an indigenous community-based science programme was applicable to the Ngāti Whakaue context and what this may look like. The research question was: "How do schools include Ngati Whakaue in science education?" Figure 6.1 was first presented in Chapter Three of this research to represent an approach to science education that recognised Ngāti Whakaue.

Figure 6.1 Proposed approach to Ngāti Whakaue science education



The overall finding of this research was that there was limited evidence of the proposed principles and the context of Ngāti Whakaue being recognised and implemented in science education in the Ngāti Whakaue setting. Figure 6.2 is a diagram which displays the researcher's view of the current state of Ngāti Whakaue science education. The two sets of disjointed arrows represent first, the limited implementation of the proposed principles and second, the disconnectedness in relationships between groups of participants, Ngāti Whakaue and the science curriculum.

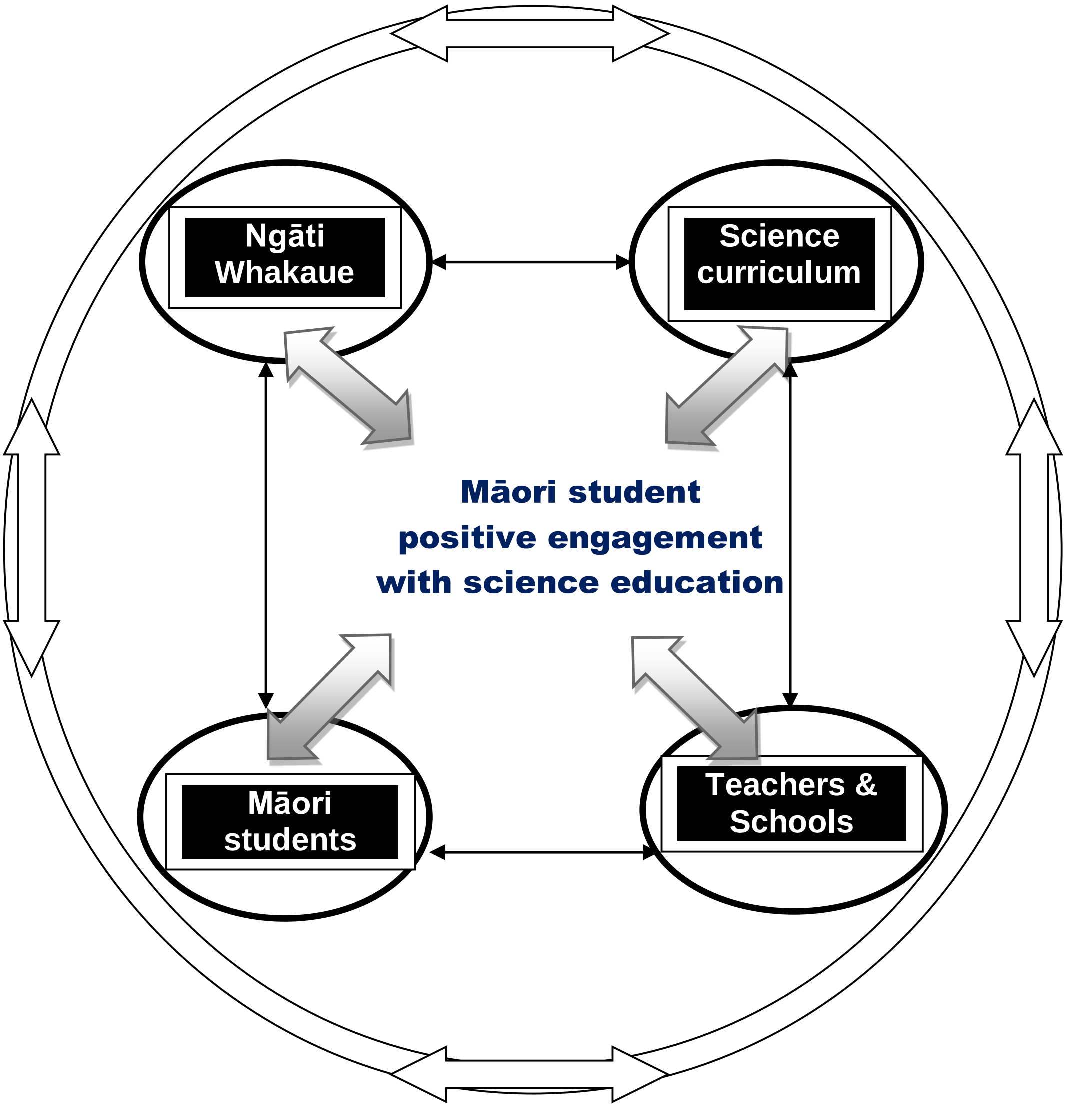
Figure 6.2 Current state of Ngāti Whakaue science education



However, three enabling themes were identified in this research (Section 5.7) that could possibly improve the implementation of the proposed principles and working relationships between each group. These themes were: the importance of good relationships between students, teachers, schools and Māori communities; the inclusion of practical engagement with Māori content; and education outside of the classroom, engaging with authentic and unique Māori locations such as marae. Figure 6.3 includes the enabling themes for Ngāti Whakaue and other indigenous communities to consider if they choose to develop and implement an indigenous community-based science education programme.

The added encompassing circle with two-directional arrows represent the enabling themes being enacted by any one of the groups including: Ngāti Whakaue (or another indigenous community), science organisations, teachers and schools, and students. Each theme supports the implementation of each of the proposed principles. An example of how the final model of an approach to Ngāti Whakaue science education (see Figure 6.3) could be implemented is given in the concluding section of this chapter (see section 6.9).

Figure 6.3 Proposed approach to Ngāti Whakaue science education



KEY

Proposed principles in practice

Working relationships including tensions and challenges

Enabling themes

6.8 Recommendations

The main aim of the current research was to contribute to Ngāti Whakaue education, specifically in the area of science education. A proposed set of principles for an indigenous community-based science programme was the main research tool used as a framework to explore participants' perceptions and understandings of science, Māori culture, and Ngāti Whakaue. The research findings and critical discussion were organised through links to the six principles of the proposed indigenous community-based science programme. The intended audience for the findings of this research is first and foremost Ngāti Whakaue and schools in the Rotorua community. Other possible interested parties include Māori and other indigenous communities, teachers, schools, teacher educators, science organisations, and education policy-makers.

The first limitation stated earlier in the current research was that Ngāti Whakaue is only one contributor to the society in Rotorua and others groups and factors may also influence how Māori students positively engage with science education. These might include the students themselves, their families, friends, sports and recreational clubs, businesses and workplaces, and science organisations. These groups were all mentioned to some extent in the participants' responses; however, wider research would have to be conducted to understand other groups' influences in engaging Māori students in science education.

The current research is an exploration of only some members of the community of Rotorua and their interaction with and perceptions of science education. This exploration has been conducted and interpreted by one member of the Rotorua community. The research findings may only be applicable to the Rotorua and Ngāti Whakaue community. However, the intent is to share stories from one specific group of people and offer possible opportunities for others in relation to national and international issues in Māori and indigenous science education.

While case studies are highly contextual, and therefore not generalizable, the inclusion of details of the context, participants and methods used for this study enables others to identify the applicability of this study to their own context. While this research offers a perspective from a secondary school setting, aspects of this context will be similar to other educational sectors and therefore maybe applicable. English and Māori medium settings were chosen as this is the reality of secondary school classrooms in Aotearoa New Zealand. This research does not intend to provide a comparison of the school settings.

Finally, this research has always intended to provide a pragmatic approach to the science curriculum to address the positive engagement of Māori students with science education. The research has identified some key issues in science education, some as a result of differing epistemological views of indigenous knowledge and science held by different groups. This research promotes a complementary view that both indigenous and science knowledge can contribute to the positive engagement of Māori and other indigenous students in science education. One of the final sections of this chapter describes a proposed Ngāti Whakaue science topic that could be used as a guide for the Rotorua community and their science education programmes.

6.8.1 Partnership and Power-sharing

The partnership and power-sharing principle in practice aims to ensure students, teachers, schools and indigenous communities are all part of the decision-making processes about what is included in science education programmes. This principle represents Māori communities making decisions and choices about curriculum content, pedagogy, and delivery. This principle was not strongly reflected in the findings of this research as most participants had little to no Māori content included in their school science learning and limited evidence of any partnerships between each of the groups.

Recommendations for schools and their science programmes include the need to:

- Allow students to lead the direction of investigations while teachers provide resources and make links to school requirements;
- Establish and maintain partnerships with Māori communities to acknowledge Māori knowledge as an integral part of science learning; and
- Develop support systems for students and teachers to improve the inclusion of Māori culture in the science classroom.

Recommendations for Ngāti Whakaue to support schools and their science programmes include the need to:

- Establish clear guidelines about the purpose and outcomes of partnerships with schools;
- Include students and their learning as a key component of these guidelines; and
- Support local elders and other members of the local community with how to best share specialised knowledge to support teachers and students.

6.8.2 Shared Values and Aspirations

The shared values and aspirations principle aims to ensure an indigenous worldview is included in science education programmes, including cultural perspectives about identity, knowledge and language. All groups of participants had varied views and experiences with Māori but practical engagement in school science was limited. Local elders and students viewed marae as the most common place for Māori activities to occur.

Recommendations for schools and their science programmes include the need to:

- Access professional development for English medium teachers to include Māori language in their teaching;
- Access professional development for Māori medium teachers to upskill their science content and pedagogical knowledge; and

- Engage with the local Māori community to identify local terminology and develop a set of cultural standards.

Recommendations for Ngāti Whakaue to support schools and their science programmes include the need to:

- Support the provision of teacher-centred Māori language professional development for English and Māori medium schools; and
- Engage with schools to identify local terminology and develop a set of cultural standards for science education in Ngāti Whakaue.

6.8.3 Culturally Responsive Pedagogy

The culturally responsive pedagogy principle advocates the interchange of teacher–student roles in science education programmes as a means to understand each other's cultural backgrounds and associated bodies of knowledge. In practice, this principle would involve indigenous students and teachers first valuing each other's prior knowledge, backgrounds and perspectives, and the inclusion of both Māori and science knowledge in the science classroom.

All groups of participants provided a wide range of contexts for learning about science in their everyday lives but limited in the school setting. No examples of Māori contexts were given. All groups of participants stated their enjoyment of school science depended on the teacher. This was contradictory to students stating clear science career goals; however, teachers had limited knowledge of their students' aspirations. Kaumātua thought students should pursue careers to contribute to their people, which some students agreed with. Teachers and kaumātua advocated for learning school science outside of the classroom; however, most students saw school as the central location for learning school science.

Recommendations for schools and their science programmes include being able to:

- Develop an indigenous knowledge framework to support with clear understandings from indigenous and Western science knowledge systems; and
- Access support from students' whānau and community to learn about their students' indigenous knowledge and experiences.

Recommendations for Ngāti Whakaue to support schools and their science programmes include being able to:

- Support the development of a Ngāti Whakaue science curriculum framework with clear understandings of Ngāti Whakaue and science knowledge systems; and
- Provide schools with a range of sources to include both Ngāti Whakaue and science perspectives.

6.8.4 Resourcing

The resourcing principle advocates accessing of appropriate resources to ensure sufficient capacity, capability, implementation and monitoring support to include an indigenous perspective in science education programmes. In practice, the inclusion of local indigenous elders and other local advisors with knowledge unique and relevant to the culture of a specific community would be a vital component of science education. Local physical resources and environment would also be important as well as local practices that preserve these areas.

This principle was evident as all groups of participants had ideas about how Ngāti Whakaue could be included in school science. However, all groups of participants had limited or no school science experiences that included Ngāti Whakaue content. Participants identified some possible resources and processes that could support schools to include Ngāti Whakaue in their science programmes. These included local kaumātua, historians, marae, and local government councils.

Recommendations for schools and their science programmes include the need to:

- Access sufficient funding from a range of sources to support students, teachers and local Māori with their shared science projects; and
- Ensure a range of communication tools are used to disseminate the latest information, developments and materials of shared science projects to students, schools and applicable Māori communities.

Recommendations for Ngāti Whakaue to support schools and their science programmes include the need to:

- Support schools with funding to support students and teachers and local shared science projects; and
- Promote Ngāti Whakaue as a viable resource and opportunity for students' vocational future.

6.8.5 Collaboration

The collaboration principle promotes collaborative processes and systems to ensure the implementation of both indigenous and science bodies of knowledge in science education programmes. In practice, this principle would involve students, schools, teachers and Māori communities working together in the delivery of science programmes that include both Western and Māori perspectives. There was minimal evidence of teachers working collaboratively with Māori communities. Story-telling was proposed as a collaborative pedagogical approach. Kaumātua again suggested the use of marae as the key location for teaching Māori science education.

Recommendations for schools and their science programmes include the need to:

- Develop a collaborative framework to engage with Māori communities and outside science organisations modelled on components of the pōwhiri or Māori welcoming process; and

- Involve students in decision-making processes with their community.

Recommendations for Ngāti Whakaue to support schools and their science programmes include the need to:

- Seek input from parents and schools in regards to science education initiatives; and
- Develop a collaborative framework for schools and Ngāti Whakaue modelled on Ngāti Whakaue protocol.

6.8.6 Local Context

The local context principle promotes the inclusion of local phenomena, including local indigenous communities and associated local issues, in science education programmes. All groups of participants connected their sense of belonging to a place with being with loved ones. Again, there was limited evidence of this principle in practice and some disconnect between students, teachers, and the Māori community.

Recommendations for schools and their science programmes include the need to:

- Provide concrete learning opportunities associated with their students' reality or location for students to make a contribution to their immediate environment; and

- Access and include local Māori knowledge to promote the existence of varied Māori perspectives in their teaching and learning.

Recommendations for Ngāti Whakaue to support schools and their science programmes include the need to:

- Be involved in learning opportunities with schools; and
- Provide access to local knowledge and phenomena.

6.9 Proposed Ngāti Whakaue Science Topic

This section offers an example of a Ngāti Whakaue science topic. Indigenous community-based science education programmes were successful when students, teachers and schools worked alongside indigenous communities (Aikenhead, 2001; Barnhardt, 2005; Barnhardt & Kawagley, 2005; Kawagley et al., 2010). The importance of relationships was identified in this research as a key enabler to ensure a successful Ngāti Whakaue science education programme. Science programmes that included practical engagement with indigenous topics that involved learning outside of the classroom were also a fundamental part of indigenous community-based science programmes (Barnhardt & Kawagley, 2005). This approach aligns with the other two enabling themes of including practical engagement with Māori culture and local marae as part of science programmes as a means to positively engage Māori students in science education.

Specifically, Table 6.1 combines a Ngāti Whakaue focus topic, with links to the three key enabling themes and each principle of an indigenous community-based science programme. The first overarching section identifies how each enabling theme could be implemented as part of the chosen science topic. Next, each principle is given a section which identifies and links to broad objectives from *Te Marautanga o Aotearoa* (2008), the *New Zealand Curriculum* (Ministry of Education, 2007), Ngāti Whakaue-specific and science big ideas, suggested Māori and science concepts and place-based education (PBE) pedagogy (Table 3.2), and suggested activities to explore these ideas and concepts. The purpose is to offer teachers, schools, Māori communities and science organisations an example of combining themes, principles, ideas, concepts, curricula and activities as a means to positively engage Māori students with science education programmes.

This thesis has chosen the prominent Ngāti Whakaue ancestor Pukaki (Stafford, 1986), as the focus of this science topic. Pukaki has a unique legacy that spans from being an inspiring leader during his mortal life; honoured and immortalised as a carved figure by his people (see Image 6.1); exhibited as a museum artefact; an international ambassador and his carving's image imprinted as a national New Zealand icon (Tapsell, 2000).

Image 6.1 Carving of Pukaki

Table 6.1 A Ngāti Whakaue example of a science topic – Pukaki

Evidence of Enabling Themes		
Relationships	**Practical engagement with Māori culture**	**Marae as a central science learning site**
Student led investigations Teachers access local elders and experts Local elders and experts involved in school initiated investigations	Local iwi artefacts and Māori carving practices are examined Local iwi history and stories about artefacts are shared	Field trip visits to local marae Discussions with local elders at marae
Partnerships and power-sharing – "How content is chosen?" ***Students, teachers, schools and indigenous communities are all part of the decision-making processes of what is included in science education programmes*** *Te Marautanga o Aotearoa* (Ministry of Education, 2008) aims for students to be able to apply knowledge of science to community decisions and actions, in order to think about iwi and wider issues impacting on the individual, society and the environment. (p. 55) *The New Zealand Curriculum* (Ministry of Education, 2007) states that by studying science, students use scientific knowledge and skills to make informed decisions about the communication, application, and implications of science as these relate to their own lives and cultures to the sustainability of the environment. (p. 28)		

Ngāti Whakaue Big Idea *Māori concept Kaitiakitanga*	**Science Big Idea** *Science concept Sustainability*	**Suggested Activities** *PBE – Reflective learning*
Pukaki the carving sits in Rotorua Museum to be shared with the world alongside other treasured artefacts of the Te Arawa and Ngāti Whakaue people.	Ancient artefacts need to be examined and their properties tested to provide the best preservative care and conditions.	Field trip to the Rotorua Museum. Research preservation testing methods with the museum and other science groups. Discussions with local elders about their knowledge and experiences with Pukaki the carving.

Shared values and aspirations – "What content is to be included?"
An indigenous worldview is included in science education programmes, including cultural perspectives about identity, knowledge and language.

Te Marautanga o Aotearoa states that students will have sensitivity to the difficult issues of their world which will encourage students to find ways in which these can be overcome (Ministry of Education, 2008, p. 53).

The *New Zealand Curriculum* (Ministry of Education, 2007) states that students learn how science ideas are communicated and to make links between scientific knowledge and everyday decisions and actions (Ministry of Education, 2007, p. 28).

Ngāti Whakaue Big Idea *Māori concept – Te reo Māori*	**Science Big Idea** *Science concept – Dissemination*	**Suggested Activities** *PBE – Citizenship education*
Pukaki the ancestor's legacy is captured in many traditional Māori practices such as waiata and whaikōrero.	Scientists share results of examinations and testing with their colleagues and other interested parties to invite critique and evaluate conclusions.	Learn local waiata associated with Pukaki from local experts. Discussions and observations with science experts evaluating the findings and their application, and appropriate dissemination processes.

Culturally responsive pedagogy – "How content will be delivered?"
The interchange of teacher student roles in science education programmes as a means to understand each other's cultural backgrounds and associated bodies of knowledge.

Te Marautanga o Aotearoa states that science knowledge is a product of human culture, and belongs to all cultures. Science is knowledge about the natural world and the place of humanity in that world. It involves testing ideas about sensory experience of the world; it is flexible, fallible knowledge, which is continually reviewed and updated (Ministry of Education, 2008, p. 53).

The *New Zealand Curriculum* (Ministry of Education, 2007) states that students come to appreciate that while scientific knowledge is durable, it is also constantly re-evaluated in the light of new evidence. They learn how scientists carry out investigations, and they come to see science as a socially valuable knowledge system (Ministry of Education, 2007, p. 28).		
Ngāti Whakaue Big Idea *Māori concept – Pēpeha*	**Science Big Idea** *Science concept – Investigations*	**Suggested Activities** *PBE – Experiential learning*
Pukaki the ancestor accomplished many achievements for the betterment of his people	Many scientists hypothesise, examine, research and draw conclusions for the betterment of their communities.	Learn local stories about the achievements of Pukaki with local experts. Discussions between students, teachers, local and science experts about what they want to achieve through science education.
Resourcing – "What support is needed?" **Accessing of appropriate resources to ensure sufficient capacity, capability, implementation and monitoring support to include an indigenous perspective in science education programmes.** *Te Marautanga o Aotearoa* (Ministry of Education, 2008) advocates access to the highest professional levels in the world of science is an imperative, as is retaining respect for the natural environment and all its inhabitants (p. 53).		

The *New Zealand Curriculum* (Ministry of Education, 2007) advocates that students also learn that Earth provides all the resources required to sustain life except energy from the Sun, and that, as humans, we act as guardians of these finite resources. Students can then confront the issues facing our planet and make informed decisions about the protection and wise use of Earth's resources (p. 28).		
Ngāti Whakaue Big Idea *Māori concept – Marae*	**Science Big Idea** *Science concept – Process models*	**Suggested Activities** *PBE – Pathways and resourcing*
Pukaki the carving is one example of the traditional Māori art of whakairo or carving. Different tribes use different materials and techniques.	Carving materials and tools have different properties that need to be tested to achieve the best result.	Field trip to local marae to view different carved artefacts. Field trip to local carvers. Conduct investigations about different properties of carving materials alongside local science experts.
Collaboration – "Who delivers content?" **Collaborative processes and systems to ensure the implementation of both indigenous and science bodies of knowledge in science education programmes.**		

Te Marautanga o Aotearoa (Ministry of Education, 2008) states that science assists the Māori world to embrace the future. Linking together traditional and modern knowledge enables new knowledge bases to develop and be extended. The student is able to develop their own 'baskets' or viewpoints on knowledge, as a foundation for studying those of other cultural origins (p. 53). The *New Zealand Curriculum* (Ministry of Education, 2007) states that students learn how scientists carry out investigations, and then they come to see science as a socially valuable knowledge system. Students learn that Earth's subsystems are interdependent and that all are important. They come to appreciate that humans can affect this interdependence in both positive and negative ways (p. 28).		
Ngāti Whakaue Big Idea *Māori concept – Pōwhiri*	**Science Big Idea** *Science concept – Collaborative practices*	**Suggested Activities** *PBE – School community partners*
Pukaki the carving was part of the 'Te Māori' exhibition which was the first touring international exhibition of Māori artefacts. The purpose of the tour was to share the Māori culture with the world.	A common practice for many scientists is to share their work locally, nationally and internationally.	Research accounts of the 'Te Māori' exhibition to identify what scientific methods were involved to exhibit artefacts safely. Accounts could be from local experts and science experts involved in similar exhibitions.
Local context – "Where is the programme delivered?" **The inclusion of local phenomena, including local indigenous communities and associated local issues, in science education programmes.**		

Te Marautanga o Aotearoa (Ministry of Education, 2008) states that the Ō Mataora (Natural World) strand is metaphorically associated with the majority of the traditional familial deities, which collectively represent a Māori system of organising and understanding the natural world and the relationships between all living things. It reminds us to respect the mauri (life force) of all things discovered, consumed, or used by humans (p. 54). The *New Zealand Curriculum* (Ministry of Education, 2007) states that the Living World strand is about living things and how they interact with each other and the environment. Students develop an understanding of the diversity of life and life processes, of where and how life has evolved, of evolution as the link between life processes and ecology, and the impact of humans on all forms of life (p. 28).		
Ngāti Whakaue Big Idea *Māori concept – Tūrangawaewae*	**Science Big Idea** *Science concept – Interdependence*	**Suggested Activities** *PBE – Use of the environment*
Pukaki the ancestor and carving originated and were based in the marae setting.	Many science activities can be observed and conducted in a marae setting.	Field trips to local marae. Collaborative projects with local elders and science experts based on local issues.

6.10 Contribution to Research

In summary, the first offering this thesis adds to current research is the examination of commonalities of existing indigenous community-based science programmes. Specifically, this thesis identified a set of principles that have been supportive in addressing common issues in science education for indigenous students, including Māori. The second contribution this thesis offers is contextualising this study to the New Zealand setting by linking the principles identified in international literature to Kaupapa Māori theory and Kaupapa Māori science education theory. The next contribution to research was the use of these principles with links to Kaupapa Māori theory as a methodological tool to investigate one Māori community's perceptions and engagement with science education. The fourth contribution this research offers is the identification of three enabling themes that could possibly facilitate improved engagement with, and outcomes for, science for Ngāti Whakaue and other indigenous communities. These themes were: the importance of good relationships between students, teachers, schools and Māori communities; the inclusion of practical engagement with Māori culture; and education outside of the classroom, engaging with authentic and unique Māori locations, such as marae. An assertion that this research offers indigenous science education is that science programmes need to acknowledge and include important relationships with people **and** places, in Māori students' lives beyond the classroom, to improve their engagement. This thesis supports this assertion by including a model example of how an indigenous community-based science programme could be implemented in the research focus community of Ngāti Whakaue.

6.11 Concluding Statement

My overall aim as a researcher is to contribute to Māori communities and other indigenous peoples in the area of education. My aim for this thesis was to contribute to the wider kaupapa of education by providing a pathway to improving Māori student engagement with science education. I think I have achieved this aim through the identification of positive elements of indigenous community-based science programmes and contextualising these to meet Māori community aspirations. This aligns with my current view of Māori education, in that initiatives aimed at supporting Māori student achievement should be developed with Māori communities, based on their perceptions of being Māori and measures of education success.

In relation to science education, I aspire for Māori students to have access to the opportunities that I had, including having their love of science nurtured at home and at school. I also desire for young Māori to have the choices I had, that is to become a scientist, teacher or academic and pursue their careers in the Māori language if they so choose. I want Māori students to have the freedom to question, critique and challenge their experience of science education. I am committed to being part of programmes that allow these aspirations.

More immediately, I want to be a part of Ngāti Whakaue science education initiatives, including professional development with teachers and schools, which has been a specific focus area for my iwi. I hope the principles and enabling themes I have identified could be part of the planning, development and implementation of Māori community-based science programmes. Nō reira, ka whakakapi au nā te reo ohaaki o tōku nei iwi, “Ngāti Whakaue Iho Ake”.

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Appendix One – Individual interview and focus group questions

Individual interview and focus group questions

Background questions

Students – Name? Age? Year at school? Tribal affiliations? Science subjects studying?

Teachers – Name? Where from? Years teaching? Science subjects teaching?

Kaumātua – Name? Tribal affiliations?

Perceptions of place – Local context

- Describe a place that is special and significant place to you and a place in Rotorua that is special and significant to you.
- If I was a first time visitor to Rotorua, where should I visit? What local stories do you know about Rotorua?
- How did you learn them? Why are these places important to you?

Perceptions of science – Culturally responsive pedagogy

- Describe places where you see science happening. What sorts of activities involve science?
- What is your most favourite science activity to be involved in? Who did you learn about science from?
- What sort of science activities do you involve yourself in outside of school? Who with?
- What do you enjoy most about these activities?

Perceptions of school science – Culturally responsive pedagogy

Past (for elders and teachers only, adjusted to present tense for students)

- What did you enjoy most about science at school? Why? What were your favourite topics? Why?
- Who did you learn the most about school science from at school? Why?
- Where else besides the classroom or lab did you learn school science? Where was your preferred place to learn school science?

Present (for teachers only, adjusted to past learning for elders and present learning for students)

- What are your favourite topics to teach? Why? What are some topics you would like to teach but can't?
- What are some topics you used to enjoy teaching, but can't teach now?
- Where else besides the classroom or lab do you teach school science? Where is your preferred place to teach school science?
- What places in Rotorua outside of the classroom have you taught school science?
- If you haven't taught school science outside of the classroom, where would you like to?
- What local issues do you include in your school science teaching?
- What careers do you see your students studying school science working towards?

Perceptions of Māori culture – Shared values and aspirations

From your understanding of things Māori:

- What do think makes Māori culture unique from other cultures?
- What are your favourite things about Māori culture or things that you associate with things Māori?

- What are some significant Māori places in Rotorua? What are some examples of unique Māori activities?
- How are you involved in these activities?

Perceptions of Māori culture and science – Collaboration

From the examples of Māori activities that you have described:

- Describe your understanding of any science involved. Are there any other Māori activities you know of that involve science?
- Where do these activities take place? Who is involved?
- Are there any stories you know of that describe Māori science activities? How are you involved in these activities?

Perceptions of Māori culture and school science – Partnerships and power-sharing

What do you consider to be a 'Māori' science topic? What 'Māori' topics have you included in your teaching?

- What are some other 'Māori' topics that you are planning to teach in the future?
- What local knowledge have you included in your teaching? What support resources are available to support you?
- What do you think might stop you from covering Māori science topics?

Perceptions of Ngāti Whakaue – Resourcing

Using the setting of Ohinemutu (Ngāti Whakaue settlement):

- What history/stories do you know about this place? What science activities happen there?

- What sort of school science teaching activities could happen here? What past or present issues do you know about this place?
- What could be your role in teaching about local issues? What support would you need, e.g. resources, scientists, locals?

Appendix Two – Ethics Approval

5 July 2010

Hiria McRae
Lecturer / Facilitator
Victoria University of Wellington Faculty of Education
C/- School of Te Kura Māori
Donald Street
Wellington

Dear Hiria

RE: Ethics Application TKM/2010/45: RM 17702

I am pleased to advise you that your ethics application **'Ngati Whakaue Iho Ake - Mātauranga a Iwi / Tikanga a Iwi - An Iwi Science Education Exploration'** with the requested amendments, has been approved by the Victoria University of Wellington Faculty of Education Ethics Committee. Please note that the approval for your research to commence is from the date of this letter.

Best wishes for your research.

Yours Sincerely

Dr Sue Cornforth

Co-Convener
Victoria University of Wellington Faculty of Education Ethics Committee

Appendix Three – Sample Information and Consent Forms

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

INFORMATION SHEET FOR PRINCIPAL / B.O.T

"Ngāti Whakaue Iho Ake –
Mātauranga a Iwi / Tikanga a Iwi - An Iwi Science Education Exploration"

Ka nui ngā mihi ki a koutou ki runga i ngā āhuatanga o te wā. Rere kau atu ngā roimata māturuturu mai i ngā kamo mō te hunga okioki, nō reira koutou kua wheturangitia, haere haere, moe mai rā koutou ki a koutou. Ka hoki mai ki a tātou ngā mahuetanga o rātou mā, tēnā rā koutou.

Ko Ngongotaha te maunga
Ko Rotorua a Kahumatamomoe te moana
Ko Tamatekapua te tangata
Ko Te Papaiouru te marae
Ko Ngāti Whakaue te iwi
Ko au te uri i raro iho nei

My name is Hīria McRae and I am a Ngāti Whakaue doctoral student and a lecturer in Te Kura Māori, Faculty of Education at Victoria University of Wellington. As part of my study for my doctoral thesis, I would like to interview a group of teachers, Ngāti Whakaue affiliated students from your school and yourself about Māori participation in science education. I am also interviewing a group of Ngāti Whakaue affiliated kaumātua.

What is the research project?

The aim of my study is to explore one Māori community's aspirations, expectations and vision for Māori student participation and achievement in science education.

Who will be involved?

1. **Kaumātua** of Ngāti Whakaue descent or have a strong association with Ngāti Whakaue.
2. **School principals** from the 8 secondary and wharekura schools in the Rotorua area.
3. **Teachers** of secondary science subjects at the 8 secondary and wharekura schools in the Rotorua area.
4. **Students** of Ngāti Whakaue descent or a strong association with Ngāti Whakaue selected by their teachers and school principals, who are considered to be achieving well in Year 11 -13 science subjects.

How will information be gathered?

I will conduct individual interviews with kaumātua, group interviews with principals and their staff and group interviews with students. Individual consent will be sought from each participant. All interviews will last approximately between 45 minutes (individual

interviews) – 90 minutes (focus group discussions) and will be conducted at a location suitable to participants.
All participation is completely voluntary and participation or non-participation will not be revealed to anyone. Consent may be withdrawn at any time up until the end of the interviews and discussions with no negative consequences. The information contained in the interviews and consent forms, which will be stored separately in my office at the Victoria University for a period of **five** years. They will then be destroyed.

I have ethical approval for this study and if at any time you have any questions or concerns about your treatment as a research participant in this study, contact Allison Kirkman, Chair of the Victoria University of Wellington Human Ethics Committee at allison.kirkman@vuw.ac.nz or 04-463 5676.

What types of questions will be asked?

The two main questions are:

"What are Ngāti Whakaue's aspirations, expectations and vision for Māori participation and achievement in science education?"

"What is Ngāti Whakauetanga and how does it support Māori participation and achievement in science education?"

These questions will be adjusted for each group of participants.

What will happen with the data?

The data gathered will be published for a wider academic audience, but the identity of participants involved will not be revealed at any point.

Kaumātua - will have their transcribed interviews sent back to them for checking, to be sent back to me before data analysis is completed. Interviews will be transcribed by me.

Teacher / Principal / Students – An email and hard copy letter will be sent to participants after all data collection has been completed, containing a list of emerging findings, to make changes before data analysis to completed. School principals can request a presentation from me about the research key findings.

A copy of my thesis will be presented to the Ngāti Whakaue Education Endowment Board who has supported my study through a generous scholarship, and as a gift to my iwi.

If you agree to participate, please indicate this decision below and return this consent form to me. If you have any questions about this research or would like to discuss any concerns prior to providing consent, please feel free to contact me at:
Email: hiria.mcrae@vuw.ac.nz,
Phone: 04-463 9602
Fax: 04-463 9548
Mailing address: VUW College of Education, PO Box 17-310, Karori, Wellington, New Zealand.

Or my supervisors:
Professor Wally Penetito
Email: wally.penetito@vuw.ac.nz
Phone: 04-463 5169

Dr. Joanna Kidman
Email : joanna.kidman@vuw.ac.nz
Phone: 04-463 5882

Principal and Board of Trustees Consent

(This information will be stored for a period of five years)

- We have read the participant information sheet and understand the nature of the study.
- We have been offered the opportunity to ask questions and have them answered to our satisfaction.
- We understand that our participation in this study is completely voluntary.
- We understand that the school and all research participants may withdraw their information up until the end of interviews and discussions.
- We understand that only Hiria McRae and her supervisors will have access to the information contained in the interviews and consent forms.
- We understand that all data and consent forms will be stored separately in the researcher's office at the Victoria University for a period of five years. They will then be destroyed.
- We understand that we will receive a copy of emerging findings that we can make adjustments to if we choose to and return to the researcher before the end of data analysis period.
- We understand that we can request a presentation of the research findings.

Please indicate the appropriate response.

We do / do not give our permission for the school's participation in this project.

We do / do not give permission for you to invite the participation of our teachers, students and principal.

We do / do not give permission for the research data collection to occur on school grounds.

__________________________________ ________________________

Principal Date

BOT Chairperson Date

GLOSSARY

The English definitions of Māori terms in this glossary are basic and some terms may have multiple or deeper meanings than provided.

ako	to teach or to learn
hā	breath or to breathe
hangi	earth oven
hāora	oxygen
hapū	sub-tribe
Hawaiki	ancestral homeland
He anga mahi tahi/mahi ngātahi	a collaborative practice framework
hui	meeting or gathering
iwi	tribe or tribal affiliation
Ka Hikitia	a New Zealand government Māori education strategy
kaitiakitanga	guardianship
kapa haka	Māori performing arts
kaumātua	local elders
kaupapa	topic or collective philosophy
Kaupapa Māori	Māori focused
kawa	procedures
kōhanga reo	Māori medium early childhood centres
kotahitanga	unity
kia piki i ngā raruraru o te kāinga	socioeconomic mediation
mana	prestige

manaakitanga	hospitality
Māori	indigenous people of Aotearoa New Zealand
marae	central meeting location
Mātauranga Taiao	Māori medium education for sustainability teacher professional development programme
Ngāti Whakaue	Māori tribe located in Rotorua New Zealand
Ngāti Whakauetanga	Ngāti Whakaue history, knowledge, language, and protocol
Ngāti Whakaue Iho Ake	proverb describing the collective values and strength of Ngāti Whakaue
Ō Mataora	Natural World strand of the Pūtaiao curriculum
ora	lifeforce or to live
pēpeha	locative proverb
pōwhiri/ pōhiri	formal welcome
Pukaki	Ngāti Whakaue prominent ancestor
pūrākau	stories
Pūtaiao	Māori medium science curriculum
rāhui	conservation practice
rongoa	medicine
Rotorua	main city in Aotearoa New Zealand
Tamatekaupa	ancestral chief of the Te Arawa canoe
tapu	sacred
taonga tuku iho	treasures passed down from ancestors
Te Anga Mātauranga	national curriculum framework

Te Arawa	Māori tribe and ancestral canoe located in Bay of Plenty New Zealand
Te Kauhua	New Zealand research and secondary school professional development programme
Te Kotahitanga	New Zealand research and secondary school professional development programme that followed on from 'Te Kauhua'
Te Marautanga o Aotearoa	Māori medium curriculum framework
te reo Māori	Māori language
tikanga	protocol
tino rangatiratanga	self-determination
tūrangawaewae	a place to stand
waahi tapu	sacred places
wānanga	group discussions
waiata	songs
waka	canoe
wero	challenge
whaikōrero	formal speeches
whakapapa	geneology
whānau	family
wharekura	Māori medium secondary schools