An Investigation into Differentiation in a Rural Aotearoa New Zealand Secondary Science Setting

He Waka Eke Noa

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Abstract

Disparity in education is a problem confronting educational researchers and practitioners. Within Aotearoa New Zealand, science education inequity is evidenced in a gap - one of the widest internationally - between high and low performers on international assessments. Māori and students of other non-dominant cultural backgrounds are disproportionally represented at the bottom end of this performance scale. Literature indicates that differentiation – the modification of curriculum and instruction to support students with academically diverse learning needs through adaptations to content, process, or product – is an inclusive teaching and learning strategy with the potential to increase educators' abilities to meet diverse students' needs. However, little research or evidence exists to provide teachers with the framework to differentiate effectively in mainstream science classrooms. This mixed methods action research (MMAR) investigation enabled a rural, bicultural Aotearoa New Zealand school community's years 9 and 10 students (ages 12-15), their science teachers and whānau (families) to firstly, share their perspectives on current classroom practice, and from these perspectives, collaboratively develop, implement and evaluate a differentiated science unit. The study utilised both quantitative and qualitative data collection strategies, including surveys, individual interviews, classroom observations, focus groups, and collaborative professional development and planning sessions. The objective was to expand the evidence base of effective teaching and learning strategies for all learners within diverse mainstream secondary science classrooms including those identified as at risk for under-achievement such as students with learning difficulties, exceptional science talent and of Māori or other non-dominant cultural backgrounds. Findings suggest there is value in teachers using differentiated materials designed for gifted learners when the gifted differentiation principles and practices are adapted and implemented in response to community input. Findings indicate that student engagement and learning in science – for Māori and non-Māori students from across the learning spectrum – improved in all aspects that teachers chose to differentiate, including: relevance of content, assessment and accommodation of student readiness, and variety and choice in process and product. From the research findings, a model of community-driven differentiation, he waka eke noa: differentiation in 3-D (teacher/student/whānau), has been conceptualised that could potentially be a strategy for increasing the quality of culturally responsive science teaching and learning that meets diverse students' needs both within Aotearoa New Zealand and internationally.

Key words: *Differentiation, Māori, Culturally Responsive, Secondary Science Education*

He Mihi

Tēnā koutou katoa, he mihi nui ki a koutou

Ko Denali te maunga

Ko Tanana te awa

Ko Amerikana, ko Tatimana, ko Teina ngā iwi

Nō Alaska ahau

Heoi anō, ko Aotearoa tōku kāinga inaianei, nō reira,

Ko Tauhara te māunga

Ko Waikato te awa

Nō Taupō-nui-a-Tia ahau

Ko Kathleen DeVries rāua ko Jerry Vander Zwaag ōku mātua

Ko Carrie Vander Zwaag ahau

Nō reira, tēnā koutou, tēnā koutou, tēnā koutou katoa

Greetings to you all, and salutations to you

My mountain is Denali

My river is the Tanana

My ancestry is American, Dutch and Danish

I am from Alaska

However, I live in Aotearoa New Zealand today, so,

My mountain is Tauhara

My river is Waikato

Taupō is my home town

My parents are Kathleen DeVries and Jerry Vander Zwaag

I'm Carrie Vander Zwaag

And so, greetings to you all once again.

Acknowledgements

Ehara taku toa i te toa takitahi, engari he toa takitini.

We cannot succeed without the support of those around us.

This thesis journey has been full of unforeseen changes within the research voyage as well as the accompanying adventure of life. I welcomed my first and second child into the world while also fare-welling the grandmother for whom I am named. Changes in supervisory panel, school enrolment, staffing, timetables, class structure and school initiatives also influenced what and how I collected and analysed my data. This PhD waka remained afloat and moving forward due to the support, flexibility and resilience of (a) supervisors and staff at Massey University; (b) leadership, colleagues and students at the school where I teach and conducted this research and (c) an incredible network of whānau and friends. As such, this section of the thesis acknowledges the contributions of key people and organisations who have made this research feasible.

First and foremost, I would like to dedicate this completed thesis to the memory of each my grandmothers, Esther Mae and Eileen Marie. Despite being two of the most intelligent, talented and capable women I have ever known, neither of my 'Grandmas' were able to attend secondary school due to whānau and financial circumstances. Their determination, however, to enable future generations, both within and beyond their whānau, to receive greater educational opportunities, fostered a value in and love for learning that influenced and bettered the lives of many, including myself. Thank you for the legacy you have provided; the values I hold dear and much of my worldview stem from your empathetic and pragmatic approach to helping others. I have no doubt that both of you would have been successful doctoral candidates had you had the opportunity.

My Christian faith is a key component of the legacy handed down through my whakapapa. As such, I would like to first acknowledge "My only hope in life and death[1]," the Lord and Saviour Jesus Christ, and the leading role that spirituality plays in guiding and shaping my decisions, values and interactions with others. I am grateful for the numerous blessings that I have experienced during this research journey including supportive supervisors, friends and whānau; stable personal and whānau health (through two pregnancies and labour!); safety in travel and financial scholarship opportunities. I hope that this thesis and future research that will

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[1] References question one of the Heidelberg catechism.

potentially evolve from it will serve as a koha, aligning with the spirit of Luke 12:48, "To whom much has been given, much will be expected."

Mum (Mom) and Dad, you are the people who have most influenced my life, guiding and supporting me in so many tangible and intangible ways, including physically, spiritually, emotionally, academically and socially. Thank you for helping me discover my passions, challenging me to be a better person, and modelling life-long learning of compassionate teachers both in the classroom and at home. You have encouraged and supported me to achieve even the dreams you deemed crazy. It is no surprise, therefore, that you have been so instrumental in helping me realise this PhD dream. Thank you for listening, brainstorming, editing, and above all, actively loving my kids ("Play cars with me, Nana!") while I converted your basement, travel trailer or any spare corner into a thesis research hideaway. I treasure the time you have dedicated to visit/stay with us in Aotearoa New Zealand during the PhD journey and hope we are able to continue the tradition long after this thesis is on the library shelf.

Tangata ako ana i te whare, tūranga ki te marae, tau ana.
A child who is instilled with meaningful values at home and cherished within family, will not only excel amongst the family but also within society and throughout his life.

Ivan and Ruth, thank you for accepting me into your whānau with open arms from day one! The heaps of scrumptious, nutritious treats provided in person or smuggled via suitcases or international post have sustained and energised me through this journey. We anticipate trips to visit you with great excitement. Your outdoor room overlooking the pond of herons, turtles, frogs, fish and the occasional Theo-driven speedboat is by far my favourite thesis work setting. I appreciate how I can truly focus at your place, knowing the kids are off enjoying themselves on another Grandpa Ivan or Grandma Ruth adventure.

Aroha mai, aroha atu.
Love received, demands love returned.

To my incredible supervisors, Associate Professor Tracy Riley and Dr James Graham, thank you for your mentorship, insight, wisdom, encouragement and challenge throughout this PhD journey. Your 'sage advice' and role-modelling of professional, academic, personal and spiritual wellbeing has been both invaluable and inspirational. Thank you, Tracy, for being the first Kiwi academic to see potential in me and to not only willingly but enthusiastically take me on board as a PhD student, sticking with me through all the life changes we've both experienced since early planning sessions in mid-2014. From home-cooked meals and kids' toys laid out for

Theo to checking up on my safety in dodgy Palmy accommodations, you exemplify a supervisor that cares for and nurtures her students holistically. James, I was equally excited when you came on board. We would not have been able to explore bicultural responsivity without you. You are the expert in education and Māori culture that I had unconsciously been searching for since beginning my Aotearoa New Zealand teaching journey. No question was ever too big, too small or too stupid; never once did I feel whakamā as I struggled to better understand and integrate cultural responsivity throughout my study. You have this amazing sense of calm about you which complements Tracy and me well. You both have an ability to critically evaluate while encouraging at the same time, fostering true manaakitanga! I will miss your weekly(ish) wisdom when this thesis is complete and hope that opportunities to partner with each of you in future teaching and research endeavours arise.

Mā te huruhuru te manu, ka rere.
Adorn the bird with feathers so it can fly.

To the members of my remarkable school community, thank you so much for the integral role you play in my life. I continue to learn from and be inspired by each and every one of you. To my principal, thank you for rekindling my love for evidence-based classroom practice and encouraging me to venture on a professional learning journey that stimulated both my mind and heart. Thank you for your determination to foster professionalism within teaching and for reminding staff that how society views the education profession is largely dependent on what/how we teach in the classroom and interact with the community. To 'Alton,' when you agreed to this journey, it was as an initial 1-yr leave from school; 2 babies and 3 years later, you have mentored 4 teachers in my place. Thank you for encouraging and believing in me despite the additional workload it provided you. Watching you in action during this study has further cemented the respect I have always held for you as a person of integrity and skilful, passionate educator. To 'Sage,' 'Casper' and 'Turin' thank you for agreeing to take this research on as your own, opening your classrooms to me and genuinely sharing the joys and struggles of teaching. You are an inspiration. To the rangatahi within our science classrooms, past, present and future, your enthusiasm and curiosity about the world motivate us to continue teaching. If more adults had the opportunity to interact with and get to know you as we do, they would carry a renewed sense of hope about the future of Aotearoa New Zealand. Thanks, specifically, to the students and whānau who took time out of busy schedules to participate in this study, reflecting on science teaching and learning to share valuable insight. The inclusion of your voice is what makes this research unique; without you there would be no responsive, 3-D differentiation to write about!

Ko koutou ki tēnā kīwai o te kete, ko ahau ki tēnei, ka ora ai ngā ākonga.
With you holding your side of the kit, and me holding my side, the students will be well.

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Recommendations by previous graduate students detailing the library's superb support distance education were a key factor for me in choosing Massey University over other Aotearoa New Zealand universities for my graduate studies. I can now provide similar recommendations to other potential distance students, based on my excellent experience. Thank you to all the Massey University Library staff, but Rachel, Joanna and Chris in particular, for providing excellent, equitable distance education research services. What a privilege to access hundreds of digital and print resources from my home while remaining in the rural community where I live, teach and conduct research! Chris, your on-going assistance with Endnote and other technical emergencies streamlined my referencing and prevented multiple mental breakdowns! If my Grandma Eileen had access to similar quality distance resources in the remote farming community where she grew up, I have no doubt that she would have completed secondary and tertiary school.

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Now, to the many friends and whānau, new and old, in Aotearoa New Zealand and overseas, who have supported me in the ups and downs of this journey including Nicola, Priscilla, Amy V., Justin, Hollie, Matt, Aiden, Ashley, Carol, Chelsea, Angela, Fanny, Jan, the fabulous Peez 4 and so many more. Your willingness to express (or feign) interest in thesis progress, provide a listening ear, care for my children and/or hubby during PhD research/trips, assist with meals and remind me that there is life to be enjoyed outside of the PhD realm did not go unnoticed and were greatly appreciated. Donovan, your creativity and skill transformed the waka design from my awkward PowerPoint drawing object to a vibrant visualisation, thank you! Maree, thank you for joining our crazy whānau and loving us. You have blessed us more than you will ever know! Your beautiful singing, patience and positivity have encouraged Theo and Cierra greatly. Thank you for accompanying us on the ups and downs of this journey (including a sailboat and white-water raft) and helping me keep what resembles some form of sanity.

He tangata kī tahi.

The person who speaks once and does what they said they'd do.

Theodor Lee Rameka and Cierra Lael Manaakitia. You are by far the biggest and most enjoyable surprise of this venture, providing both new challenges and love. Thank you for your patience and support as mummy pursued this dream. I look forward to learning with you as we explore God's world and discover and foster your talents, passions and interests. Your laughter, energy, curiosity, cuddles and tears have brought an incredible dynamic to our lives!

Ahakoa he iti, he pounamu.

Although small, you are precious; like greenstone.

And finally, Thomas, my husband and my partner in life. Thank you for your never-ending love and encouragement, key to this thesis completion. Your humour and pragmatic approach to our relationship and this PhD venture kept me in the waka despite the many times I wanted to jump out and swim away!

Moe atu ngā ringa raupā.

Marry a man with calloused hands, the sign of a man with a great work ethic and provider.

Thank you for caring for our children at all hours of the night and day and keeping the whānau going (groceries, cleaning, meals, transport). Modifications to your work schedule to allow me to work/zoom/travel, countless printed chapter drafts, numerous postie runs to return library books and missed rehearsals/practices (music/tennis) were all greatly appreciated.

E kore e mimiti te aroha mōu.

My love for you will never wane.

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Te Reo Māori Glossary

Āhua	physical demeanour, appearance
Ako	to teach or learn, reciprocal teaching and learning
Aotearoa	New Zealand/land of the long, white cloud
Aroha ki te tangata	respect for people
Hapū	subtribe
He kanohi kitea	the seen face, meeting face-to-face
Hiwi	hull
Hoe tere	steering paddle
Hourua	double hulled sailing waka
Hui	meeting(s)
Iwi	tribe
Ka Hikitia	Ministry of Education's Māori Education Strategy
Kahokaho	railing
Kai	food, to eat
Ka Awatea	an iwi case study of successful Māori secondary students
Kaua e māhaki	do not flaunt your own knowledge
Kaua e takahia te mana o te tangata	do not trample the rights of the people
Kaupapa Māori	by Māori, about Māori, for Māori
Kia Eke Panuku	Ministry of Education's Building on Success Initiative
Kia tūpato	to be cautious
Koha	a gift, an offering, donation
Kura Kaupapa Māori	Māori language immersion school
Māhaki	humble, humility
Mahi tahi	collaborate, work together
Mana	power, status, rights
Manaaki ki te tangata	sharing, hosting, generosity
Manaakitanga	respect, generosity and care for others
Mauri ora	wellbeing, flourishing
Mauri noho	weakening of one's wellbeing
Māori	Indigenous Aotearoa New Zealanders
Mauri	life-force

Pākehā	of European descent, originally applied to English speaking settlers to Aotearoa New Zealand
Papa noho	deck
Pikorua	greenstone pendant, twist design representing connectedness
Pou	a post, pillar
Pou manawa	mast
Pūtaiao	science
Rā kei	mizzen
Rā matua	mainsail
Rangahau	to seek, research, investigate
Rangatahi	young people, teenagers, adolescents
Rangatira	chief(s)
Rongoā Māori	traditional Māori medicine
Tangata whenuatanga	place-based, socio-cultural awareness and knowledge
Taonga	treasure(s)
Tātaiako	cultural competencies for teachers of Māori learners
Taura pā	stay (mast support)
Te Kotahitanga	education research and professional development programme
Te Kura	The Correspondence School
Te reo Māori	Māori language
Te Tiriti o Waitangi	Treaty of Waitangi
Tikanga Māori	Māori values
Tino rangatiratanga	chieftainship or full authority
Titiro, whakarongo . . . kōrero	looking, listening, speaking
Wairuatanga	spirituality
Wānanga	communication, problem-solving, to deliberate
Waka	traditional Māori canoe, vehicle
Whānau	family
Whanaungatanga	relationships with high expectations
Whakamā	to be ashamed, shy, bashful, embarrassed
Whakapapa	ancestry, genealogy
Whakataukī	proverb

Chapter 1:

Introduction

I orea te tuatara ka patu ki waho.

A problem is solved by continuing to find solutions.

Thesis Background

Despite a global commitment to increasing access to quality education for all children over the past 20 years, inequality in education has actually increased, with the poor and disadvantaged most likely to miss out on schooling opportunities (Ainscow, 2016; UNESCO, 2015). Educational disparity is a challenge for both developing and wealthy countries (Ainscow, 2016; UNESCO, 2015). Within Aotearoa[2] (land of the long, white cloud) New Zealand, science education inequity is evidenced in the persistent gap – one of the widest internationally – between high and low performers on international assessments (Caygill, Hanlar, & Singh, 2016; Cowie, Jones, & Otrel-Cass, 2011). Māori (Indigenous New Zealanders) and students of other non-dominant cultural backgrounds continue to be disproportionally represented in the bottom end of the performance scale despite research, policy and educator efforts to bridge the gap (Caygill et al., 2016; Cowie et al., 2011). Underrepresentation of non-dominant cultures also persists internationally in science education research and science-orientated professions (Chinn, 2012; Lin, Tsai, & Lin, 2014; C. Rodriguez, 2015).

Literature indicates that differentiation is an inclusive teaching and learning strategy with the potential to increase educators' abilities to meet diverse student needs in mainstream classrooms (Kelly M. Anderson, 2007; Borland, 2012; Kanevsky, 2013; Kluth & Danaher, 2014; H. Morgan, 2014; Riley, 2011; Tomlinson et al., 2003; Tomlinson & Imbeau, 2010). However, at the time of research, very few existing studies had investigated differentiation within secondary science education (Maeng & Bell, 2015). My literature review yielded no differentiated secondary science education studies conducted and reported from within the bicultural context of Aotearoa New Zealand. Furthermore, despite evidence indicating the importance of incorporating community voice in creating inclusive, meaningful, relevant learning experiences

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[2] In recognition of the bicultural context of Aotearoa New Zealand, te reo Māori (the language of Indigenous New Zealanders) is incorporated throughout my thesis. When a te reo Māori term is first introduced, the English translation directly follows in brackets. To avoid redundancy, I do not include English translations for subsequent use of repeated te reo Māori terms, providing, instead, an alphabetised glossary of te reo Māori to English translations on pages xxv and xxvi to assist readers unfamiliar with te reo Māori.

for all learners, but particularly students of Indigenous backgrounds (Ainscow, 2016; Berryman, 2017; Bevan-Brown, 2011; McKinley, 2005; Messiou & Ainscow, 2015), no previous studies approached differentiation through the integration of community perspectives from both within and outside the school setting.

My research is the first to explore the impact of differentiated science teaching and learning designed in response to community input on teachers' ability to meet student needs, promoting diversity and equity. As a science teacher with 14 years of teaching experience, I, along with my colleagues at the rural Aotearoa New Zealand secondary school where I teach, began this study to explore teacher, student and whānau perspectives of (a) how well our science teachers were meeting current students' learning needs with existing science teaching practices and (b) how we could improve the quality of our science teaching to better meet student needs and increase the effectiveness of teaching and learning in our classrooms.

My thesis aligns with current international (Coburn & Penuel, 2016) and Aotearoa New Zealand Ministry of Education (2016) aims of establishing collaborative practices and profession-led learning as 'key features' of the education system, facilitating internal and external expertise "more strategically to appropriately complement one another" (para. 3). External expertise was provided by myself as a doctoral researcher and experienced practitioner, supported by expertise of tertiary supervisors in gifted and bicultural education. The implications of my research approach for culturally responsive teaching and learning may extend beyond the sciences and Aotearoa New Zealand.

Ivankova's (2015, 2017) emerging mixed methods action research (MMAR) approach utilised in my research could forge the way for future educational research seeking to meet diverse student needs and facilitate inclusive science education. My work aligns with global (Ainscow, 2016) and national objectives (Ministry of Education, 2016) of building "professional and evaluative capabilities within and across Communities of Learning [to] support them [as they] gather, analyse and use their data and evidence to identify what matters most to generate greater equity and excellence for their students" (para. 3). Throughout the investigation, participating teachers and I were active contributors to on-going professional development via the MMAR process of *Diagnosing, Reconnaissance, Planning, Acting, Evaluating* and *Monitoring* (Ivankova, 2016).

Thesis Intent

My thesis research endeavoured to address the ever-increasing diversity that teachers like myself encounter in today's classrooms by developing differentiated secondary science teaching and learning practices. The 6-phase MMAR study, grounded in a dialectical pragmatic theoretical stance, engaged my rural Aotearoa New Zealand school's community of years 9 and 10 science teachers, students (ages 12-15) and whānau [extended family] to firstly, share their perspectives on what was currently happening in the classroom, and from these perspectives, develop, implement and evaluate a collaborative differentiation unit. This approach to differentiation incorporated multiple perspectives of how to best meet individual students' interests, strengths and needs. The research objective was to expand the evidence base of effective teaching and learning strategies for achievement and engagement of all science students – including Māori – within diverse mainstream secondary science classrooms. Practically, it sought to utilise the expertise that already existed within the school's community to provide "just-in-time, job-embedded assistance as [rural science] teachers struggle to adapt curricula and instructional practices to unique classroom contexts" (Guskey & Yoon, 2008, p. 497).

To achieve these objectives, my research addressed the following questions:

1. How is differentiation of the science curriculum evidenced and understood by teachers, students and whānau?
2. How can teachers work together collaboratively with a researcher to incorporate stakeholder input from teachers, students and whānau when planning differentiation of the science curriculum?
3. How can the principles and practices of differentiation for gifted and talented students be adapted to understand, inform and implement differentiation of the science curriculum for all learners?
4. How do teachers implement a collaboratively-designed plan for differentiation of the science curriculum?
5. How does differentiation of the science curriculum impact student learning?

The thesis structure I created to share my research design, implementation and evaluation in relation to these questions is now explained.

Thesis structure

My thesis is composed of nine chapters. Chapter 1 provides an overview of my research purpose, approach and context, as well as the structure of my thesis itself. In Chapter 2, I analyse and critique existing literature on inclusive education and differentiated instruction. Inclusive instructional complexities of lower secondary science teaching and learning are discussed, followed by the merits and challenges of differentiated teaching as a strategy of preventing exclusion. Community engagement as a tool for developing culturally responsible, relevant, and sustainable teacher and student learning is examined. The history of biculturalism within Aotearoa New Zealand society and education is reviewed and implications of Te Tiriti o Waitangi's (The Treaty of Waitangi)[3] principles of partnership, participation and protection for educational research are considered. Chapter 2 ends with an explanation of how my research fills the current gap in science teaching and learning research and practice-based literature.

Chapter 3 addresses research design. I introduce my research stance and how I applied Ivankova's (2015, 2017) 6-phase mixed methods action (MMAR) research design to my investigation. Threats to legitimacy of MMAR conclusions are discussed along with how I minimised them. Details of the methods used are reserved for subsequent chapters, as they are integral to understanding findings from each phase of the research. Chapter 4 introduces my research setting and participants, explaining my rationale for their selection. It also clarifies how my role as a practitioner-researcher impacted my research design and methods.

In Chapters 5-8, I present the methods and findings for the six phases of my MMAR investigation (see Figure 1.1). Chapters 5 and 6 describe *Diagnosing* and *Reconnaissance* efforts to gather and understand stakeholder perspectives on science differentiated teaching and learning in existing classroom practice. Chapter 5 focuses on the *Reconnaissance* quantitative data collection and analysis procedures and resulting findings collected from teacher and student online surveys. Chapter 6 details subsequent *Reconnaissance* qualitative data collection and analysis procedures and the resulting findings collected from classroom observations, teacher individual interviews and student/whānau focus group discussions.

[3] Te Tiriti o Waitangi (the Treaty of Waitangi) is a political compact, written in both English and te reo Māori, and signed in 1840 between the British Crown and Māori rangatira (chiefs). Its spirit committed to and is represented by key principles, for instance, such as partnership, participation and protection for Treaty partners on which the new government and nation state of Aotearoa New Zealand were to be built. Further discussions of the history of Te Tiriti and its bicultural implications for Aotearoa New Zealand society, research and education are explained in Chapter 2.

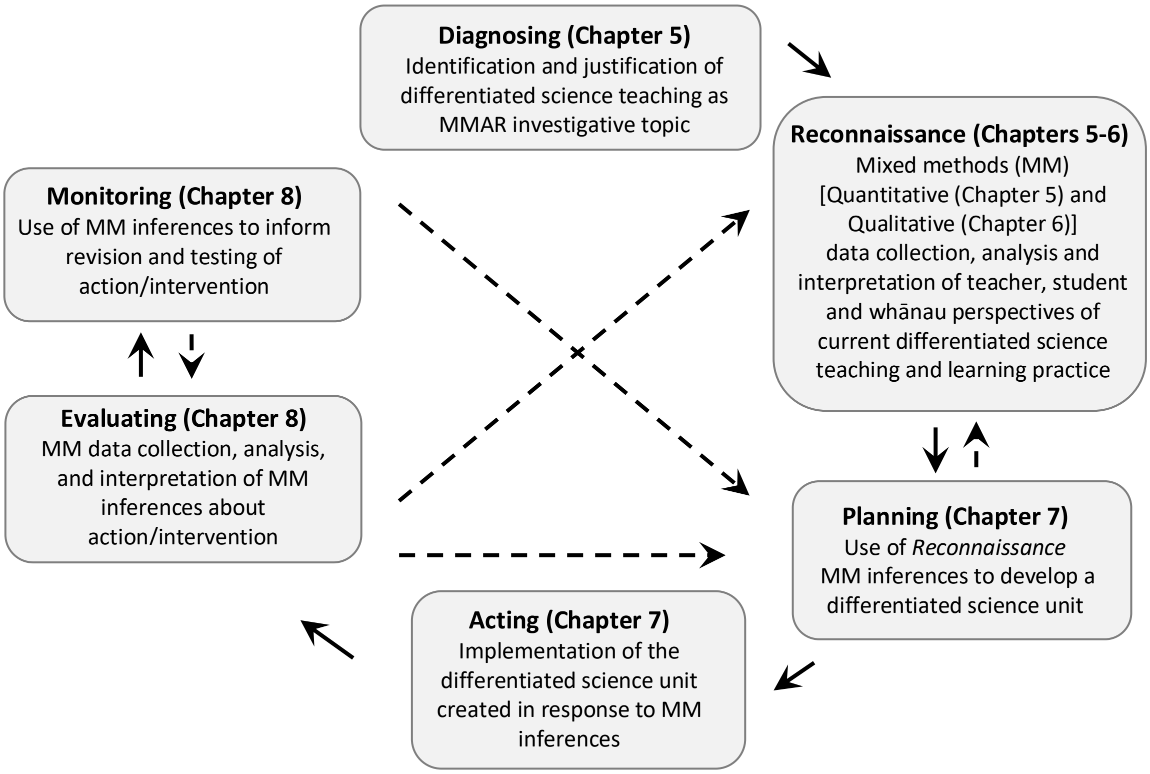

Figure 1.1: Chapter overview of Ivankova's 6-phase MMAR framework as presented in my thesis on differentiated science teaching and learning.
Adapted from Ivankova (2015, p. 61) and used with permission of SAGE Publications.

In Chapter 7, I introduce the key meta-inferences that arose from integrating *Reconnaissance* quantitative and qualitative data. I next describe teachers' responses to these findings through *Planning* and implementing (*Acting*) science curriculum differentiation that emphasised relevance, assessment and accommodation of student readiness and variety of process/product. Chapter 8 evaluates how well teachers differentiated to meet students' needs based on post-differentiation qualitative and quantitative evaluation data collected from teachers, student and whānau. In Chapter 9, I present a general discussion that links the research phases. A new framework – he waka eke noa: differentiation in 3-D – for culturally responsive, community-led differentiated teaching and learning is introduced. My thesis ends with reflections on the value of the research as well as implications and suggestions for future research and classroom practice.

Chapter 2:

Literature Review

He maha ngā kaupapa kei roto i tēnei āhuatanga hei whakaarotanga.

There are many elements to consider in this situation.

Interconnectivity and collective success underpin many countries' endeavours to ensure that the right to educational opportunity is extended to all community members regardless of gender, ethnicity, ability or economic status (Bevan-Brown, Heung, Jelas, & Phongaksorn, 2014; UNESCO, 2009). While the challenge of how to best respond to and meet the needs of diverse students is not new, the recent upswing in migration between countries has increased the complexity of this challenge (Corak, 2004) "with teachers having to take account of differences in cultures, languages, faiths and lifestyles, alongside traditional differences that exist related to pace and learning preferences" (Messiou & Ainscow, 2015, p. 246). Ainscow (2008) posits that traditional schooling does not meet these diverse students' needs, and schools are challenged to respond "to diversity through the development of practices that will reach out to those learners who are failed by existing arrangements" (Ainscow, 2008, p. 241).

This chapter analyses and critiques existing research surrounding two key concepts: inclusive education and differentiated instruction. My review of literature begins with a brief history of the limited scope of traditional inclusive education and then transitions into a description of the current international definition (UNESCO, 2009) as well as Aotearoa New Zealand's interpretations and applications of inclusive education (Bevan-Brown et al., 2014; Ministry of Education, 2012b; Riley, 2013). I then present and evaluate current research on inclusive instructional challenges characteristic of lower secondary science teaching and learning including the:

- difficulty of encouraging student growth and competency in both science methods (skills) and content (knowledge);
- underrepresentation of non-dominant culture groups within the fields of science and science education including the marginalisation of Indigenous peoples such as Aotearoa New Zealand Māori;
- persistent gap between Aotearoa New Zealand's high- and low-achieving science students (the latter of which Māori and Pasifika are disproportionally overrepresented);

- curricular and developmental challenges unique to early secondary school science such as increased demands in complex and abstract thinking, intense acquisition of unfamiliar vocabulary and the pressure to prepare for rigorous upper secondary science courses and
- necessity of mainstream science teaching and learning modifications to avoid learning exclusion for students with learning difficulties and exceptional science talent.

Strategies for preventing learning exclusion, such as differentiated teaching and learning, are next presented. I then analyse challenges to science differentiated teaching and learning including research-identified barriers of:

- teacher proficiency and beliefs in differentiated science content and pedagogy;
- teacher work-load concerns;
- school policy and structure issues and
- community influences, particularly in regards to students and whānau.

A discussion of the merit of ability grouping as an alternative to differentiation follows, leading to differentiation recommendations for practice including a description of the changes in professional learning and development within education to include teachers as active contributors. I also explore the value of community engagement in contributing to professional development and learning that is culturally responsible, relevant and sustainable. Te Tiriti o Waitangi's significance to bicultural responsiveness within Aotearoa New Zealand society and education is examined and implications of Te Tiriti's principles of partnership, participation and protection for educational research are investigated. The chapter ends with an explanation of how my study fills the current gap in science differentiated teaching and learning research and clarifies the research purpose and questions.

Search Strategy

The literature review began with an extensive analysis of Aotearoa New Zealand and international research in "secondary science differentiation" literature in 2014. I started with peer-reviewed journal articles post-2000 but expanded the search to include earlier publication dates, or when applicable, edited books, conference proceedings, periodicals, government documents and media releases. EBSCO Discovery Service (a single interface which searches across most of Massey University Library's subscribed databases) and ERIC (Education Resources Information Center) via EBSCOhost were the most heavily used databases through the Massey University Library website, supplemented by Education Source and Google Scholar. Additional resources were obtained through networks and in discussions with field experts in differentiation, culturally responsive education, mixed methods action research, science education and gifted education. Initial search results were extremely limited, so I expanded the search beyond secondary science differentiation to explore intermediate and primary school research as well. I also searched for differentiated teaching and learning research in education beyond the sciences.

Although my research focused on mainstream classroom studies, I also explored what is currently happening in both traditional and inclusive, specialised science, technology, engineering and mathematics (STEM) schools to gain a wider perspective of effective classroom practice in other settings. In addition to conducting periodic literature review searches throughout my study to keep up-to-date with recent developments in the field, I also created EBSCO alert notifications to run throughout the course of my thesis preparation to inform me immediately when new publications were produced in related differentiated teaching and learning fields. All resources were critiqued to determine their applicability to the literature review where subsequently, all relevant research studies were included in the following literature critique.

Inclusive Education

Many countries, Aotearoa New Zealand included, have turned to inclusive education as the panacea from which to meet the diversity challenge (Bevan-Brown et al., 2014; Kearney, 2013; McMaster, 2013). Traditionally, inclusive education has been linked with the rights of students with difficulties (MacArthur, 2013) to be taught in local schools, rather than segregated into special or separate classes, units, or schools (Ainscow, 2008). Today, however, the concept of inclusive education encapsulates a global concern for the right of all youth to complete a free, accessible, compulsory education that both responds to individual needs and is relevant to students' lives beyond the classroom (MacArthur, 2013).

In theory, the Ministry of Education agrees, espousing inclusion as one of its eight essential principles of curriculum decision-making. It declares Aotearoa New Zealand's education curriculum to be non-discriminatory guaranteeing that "students' identities, languages, abilities, and talents are recognised and affirmed and that their learning needs are addressed" (Ministry of Education, 2007, p. 9). In the March 2012 *Curriculum Update,* the Ministry further delineated its stance by declaring that the 'Inclusion Principle' "means valuing all students and all staff in all aspects of school life" (p. 1). In September 2014, the Ministry released an inclusive education information sheet outlining criteria for measuring the presence, participation and learning of children and young people with special needs:

- being present at their chosen school, with their siblings and friends;
- participation and engagement in class and out of class, with their peers, doing what their peers do;

- learning and achieving, experiencing success, being challenged, learning within the curriculum and enjoying things they're interested in and
- feeling like they belong, enjoy school, want to go to school and have friends.

In 2015, the Ministry of Education launched the website: *Inclusive Education, Guides for Schools.* This website provides educators with guides for meeting the needs of children with special needs and takes a stand against bullying behaviour. Culturally inclusive strategies for Māori and Pasifika students are included and exemplary inclusive schools' activities highlighted.

The Ministry of Education (2014) reports that Aotearoa New Zealand leads the world in its inclusive education provisions, "…with only 0.4% of children in special education settings separate to regular schools" (p. 9). However, the Ministry of Education neglects to mention that an Education Review Office (ERO) 2012 report found only half of schools to be mostly inclusive, 30% of schools with some inclusive practices and the remaining 20% with few to no inclusive practices. Critics (Bevan-Brown et al., 2014; Margrain, 2013; McMaster, 2013) maintain that the Ministry of Education's declaration of overtly positive statistics significantly restricts the definition and scope of inclusion. Is attendance of students with disabilities in mainstream schooling adequate evidence of effective inclusion? Definitely not, contend experts in the field (Ainscow, 2008, 2016; Bevan-Brown & Kenrick, 2013; MacArthur, 2013; Margrain, 2013; Renzulli, 2011), for "circumstances related to inclusion are often complex, dynamic and always unique" (Annan & Mentis, 2013, p. 25). Neither should the measurement of effective inclusion be limited to assessing only students with learning or behaviour difficulties. Indeed, in the Salamanca Framework for Action, the United Nations Education, Scientific and Cultural Organisation (UNESCO) (2009) advocates for a diverse support continuum to tackle the complex continuum of student needs, rather than a one-size-fits-all strategy (Riley, 2013).

Effective provision of an inclusive education that meets all students' needs requires dynamic and responsive teaching (Tomlinson, 1999; Tomlinson & Imbeau, 2010). Furthermore, unique learning demands in each subject area greatly influence the form and content of responsive teaching (Kanevsky, 2013; Maeng & Bell, 2015). In the next section of this chapter, I identify challenges to inclusive science teaching and learning, many of which are distinctive to the lower secondary science classrooms. Identified gaps in the research and suggestions for future research are integrated into the description of each of the challenges, which include:

- demand to simultaneously develop student competency in nature of science (method) and science knowledge (content);
- expectation of scientific literacy for all students, including those who do not want to pursue science as a career;

- persisting trend of underrepresentation of non-dominant cultural groups in the science profession and within science education;
- increased academic rigour and expectations;
- distinctive academic, cognitive, and social developmental changes connected with students' transition from primary to secondary school and
- exclusion risks for both students with learning difficulties and exceptional science talent.

Inclusion in the Science Classroom: Unique Challenges

Today's science educators encounter several unique challenges as they strive to be inclusive and responsive to learners: the shift to integrated methods and content; the expectation of scientific literacy for all; underrepresentation of non-dominant cultures in the sciences; the leap in breadth, depth and complexity of early secondary science content as well as obstacles for students with difficulties and exceptional science talent. Explanation of each of these challenges and implications for science education both internationally and within an Aotearoa New Zealand context follows in subsequent sections of this chapter.

The shift to integrated methods and content. Over the past century, and specifically within the last 50 years, both the nature of science and what it means to know science have evolved considerably (Brigham, Scruggs, & Mastropieri, 2011; Duschl, Schweingruber, & Shouse, 2007). Scientists have transitioned from a primary reliance on direct observation to using increasingly complex technology to assist them in forming inferences about phenomena previously unseen or unmeasured by unaided human capability (Duschl et al., 2007). As such, today's body of scientific knowledge and reasoning arises from not only experiential observation and data analysis but also "inferential chains of logic" (Brigham et al., 2011, p. 224).

In response to these changes, international science curricula have shifted away from a limited definition of science as a collection of knowledge to be memorised (National Research Council, 2012; Watt, Therrien, & Kaldenberg, 2014). Rather, science competence is demonstrated by a student's ability to develop:

- "familiarity within a discipline's concepts, theories, and models;
- an understanding of how knowledge is generated and justified and
- an ability to use these understandings to engage in new inquiry" (Donovan & Bransford, 2005, p. 398).

In this approach, nature of science processes are taught and learnt within the context of the existing framework of scientific knowledge. Teachers are expected to inclusively provide all students with substantial "experience and instruction in content as well as method in order to gain the foundation necessary to [effectively] engage in new inquiry" (Brigham et al., 2011, p. 224). All students are expected to "learn academically rigorous science" (Januszyk, Miller, & Lee, 2016, p. 28) that enables them to pursue STEM related degrees or careers and live as informed global citizens (Januszyk et al., 2016; Özgüç & Cavkaytar, 2015).

Scientific literacy for all. Gone are the exclusive days when secondary science education was reserved for the academic elite (Cowie et al., 2011; Januszyk et al., 2016; Rawlins & Walkley, 2016). Science education is now viewed as a tool to help all students academically progress and grow in their awareness of and ability to interpret and explore the environment (Cowie et al., 2011; Özgüç & Cavkaytar, 2015). This capacity, commonly referred to as scientific literacy, is purported as essential for all 21st century global citizens, regardless of country, ethnicity, gender or socio-economic background (Januszyk et al., 2016; Millar, 2006; Ministry of Education, 2007; Özgüç & Cavkaytar, 2015; Villanueva, Taylor, Therrien, & Hand, 2012). Aotearoa New Zealand, along with the majority of developed countries today, promotes scientific literacy as a key science educational objective (Ministry of Education, 2007; Özgüç & Cavkaytar, 2015). Scientific literacy entails "having knowledge of basic concepts and theories and basic skills required to establish the cause and effect relationship between the society and the environment" (Özgüç & Cavkaytar, 2015, p. 804). Aotearoa New Zealand's citizen-focused science approach was identified by Gluckman (2011), the Prime Minister's Chief Science Advisor, and reiterated by Rawlins and Walkley (2016), as having three objectives:

- utilitarian: students acquire sufficient basic knowledge that enables them to understand and appreciate how things in the technological, environmental and biological world around them work (human body);
- democratic: students attain scientific knowledge and skills needed for informed debate and dialogue regarding community science issues (climate change, fluoride in drinking water) and
- cultural/intellectual: students develop intellectual capacity to enable them to make informed consumer and everyday decisions.

Moving students towards such science proficiency in today's increasingly academic and culturally diverse inclusive secondary classrooms is no easy task (Brigham et al., 2011; Mutch-Jones, Puttick, & Minner, 2012; Özgüç & Cavkaytar, 2015). Despite the integration of the nature of science into the Aotearoa New Zealand curriculum for over 60 years, a learner-centred methods approach continues to dominate the primary sector, whereas content knowledge transmission remains the prevalent teaching structure in many secondary classrooms (Rawlins & Walkley, 2016). Indeed, as observed by Bull, Gilbert, Barwick, Hipkins, and Baker (2010), when

Aotearoa New Zealand curriculum reformers have endeavoured to adjust secondary school science to be “more ‘inclusive’, ‘relevant’ or learner-centred” (p. 6), fervent resistance has arisen from scientists and many science teachers over concerns that the science content will “be diluted – or ‘dumbed down’ – by teaching approaches designed to meet the needs of learners” (p. 6). Such a commitment to a base discipline of knowledge is more prominent in science than any other Aotearoa New Zealand curriculum area and may actually be contributing to “secondary school science education’s limited success in engaging a diverse range of today’s young people in studying science for its own sake” (Bull et al., 2010, p. 7).

Underrepresentation of non-dominant cultures in the sciences. Although scoring consistently high on 15-year-old school pupils' secondary science international assessment tests such as the Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS), Aotearoa New Zealand exhibits one of the greatest international gaps between high and low science performers, with Māori and Pasifika students disproportionally represented in the lower end of the scale (Caygill et al., 2016; Cowie et al., 2011). Both within Aotearoa New Zealand and on an international scale, students from non-dominant cultures, especially those of Indigenous origin, may frequently experience marginalisation or fewer opportunities to learn science than their culturally dominant peers (Chinn, 2007, 2012; McKinley, 2005; McKinley & Gan, 2014; Alberto Rodriguez, 2004; L. T. Smith, 2012; Tolbert, 2015). Indeed, L. T. Smith (2012) observed that in many academic disciplines, “one’s Indigenous identity has to be masked, hidden from view, as a precondition of success” (p. 352) with “very few [Indigenous people] in the sciences” (p. 352) having actually succeeded.

Perhaps this lack of opportunity contributes to the on-going underrepresentation of non-dominant cultures in fields of international science and science education previously observed by Pomeroy (1994) and more recently by Chinn (2012), Lin et al. (2014), and Rodriguez (2015). Rodriguez (2015) asserts that science education academia must become more inclusive of local education researchers who understand and represent the needs, perspectives and interests of the schools within their communities. He argues that rethinking science education could provide the underrepresented “with more spaces to be heard” (p. 1062) and contribute to “a more heterogeneous world with a diversity of solutions to the contemporary issues that diverse communities face” (p. 1062). Aotearoa New Zealand education researcher, Ritchie (2016), agrees, sounding the clarion call for those of dominant cultural grouping to “recognise, foster and support the transformative potential” (p. 35) of non-dominant cultural approaches to research and education that have the potential to serve all community members, rather than the culturally dominant status quo. McKinley (2005), also an Aotearoa New Zealand education researcher, concurs, exposing a specific need for new studies to counter the lack of current science education research into effective classroom practice that investigates Indigenous students' needs through the context of "language, culture, traditional indigenous knowledge, teacher knowledge and expectation, student expectation, cognitive conflict and [or] indigenous community needs and aspirations" (p. 237).

A mauri ora approach to 'funds of knowledge' science education. Research into science education diversity and equity has shown that when minoritised students experience learning opportunities to "be themselves, contribute to the production of knowledge, draw from household and community practices as intellectual resources for science learning and receive appropriate scaffolding while engaging in complex and meaningful academic tasks" (Tolbert, 2015, p. 1325) learning outcomes improve (Barton & Tan, 2009; Tolbert, 2015). Within the Aotearoa New Zealand context, M. Durie (2016) uses the term mauri ora (wellbeing) to help educators "understand how identity, language and culture are essential for students' wellbeing and sense of belonging in schools" (Poutama pounamu, 2017, para 1).

Mauri (life-force) denotes the "particular vitality, integrity, uniqueness and energy that exists within every person, ora refers to one's holistic wellbeing" (Poutama pounamu, 2017, para 1). M. Durie (2016) argues that mauri ora, or wellbeing, is demonstrated by: an alert and inquiring mind; enlightened spirit; functioning, pain-free body and nurturing, mutually beneficial relationships. Relationships that are disempowering or humiliating create a loss of hope and increase apprehensiveness, weakening an individual's mauri to a state of mauri noho often visible physically in one's eyes and āhua (physical demeanour) (M. Durie, 2016; Poutama pounamu, 2017). Berryman, Eley, Ford, and Egan (2016) argue that to foster "sustained systemic change" (p. 65) in which schools provide equity and excellence for all students, including students of non-dominant cultures such as Māori, educators need "the will and the professional skills" (p. 54) to facilitate an inclusive learning environment where students' mauri is nurtured and strengthened. Such culturally responsive pedagogy is grounded in "ownership of the personal and the public responsibility to use power, privilege and position within schools to promote social justice" (p. 65). This includes allowing students to "use their own cultural toolkit (Bruner, 1996) or prior knowledge and experiences to make sense of and understand the curriculum" (Berryman & Eley, 2017, p. 104).

This student-centred approach to education is often referred to in international literature as a 'funds of knowledge' approach to education (Ebersole, Kanahele-Mossman, & Kawakami, 2016; Moll, Amanti, Neff, & Gonzalez, 1992). Ares (2011) describes teachers' engagement in culturally relevant teaching as 'crossing spaces' and encourages educators to transform conventional teacher-centred power dynamics to create new social spaces where students are the driving force for teaching and learning processes. Research indicates that teaching and learning that incorporates marginalised students' passions, interests, concerns and activities has been shown to positively influence student identity, participation, and academic achievement (Barton & Tan, 2009; Berryman, 2017; Berryman, SooHoo, & Nevin, 2013; Tolbert, 2015). Webber's (2012, 2015) findings in the Ka Awatea project, a survey of 66 Aotearoa high-achieving Māori years 11-13 (ages 15-18) secondary school students, reveal that "identity, intelligence and success [are] situated and mediated by, social contexts and social group memberships" (2015, pp. 135-136). A 'funds of knowledge' (Moll et al., 1992) approach to teaching and learning requires educators to research what is happening outside of their classrooms, including community-based practices of their students and whānau, to better understand and incorporate the rich and meaningful resources students bring to their classrooms (Moje et al., 2004; Moll et al., 1992; Tolbert, 2015).

How to best nurture mauri ora and incorporate "students' funds of knowledge as resources for meaningful and transformative science learning experiences is an on-going challenge" (Tolbert, 2015, p. 1328) for educators that necessitates a support structure (Berryman & Eley, 2017; George, 2013) that may include culturally relevant professional learning opportunities (Aikenhead & Elliott, 2010; George, 2013; C. C. Johnson, 2011) and mentoring (Berryman & Eley, 2017). Further science education research, including those led by practitioner science educators (McGinnis, 2013), is needed to help educators better teach inclusive, culturally relevant, science effectively (Tolbert, 2015; Villanueva et al., 2012).

Science teaching and learning challenges unique to the middle years. In addition to the method-content and cultural challenges faced by inclusive science educators, the intermediate and lower secondary years (ages 12-15) present teachers with unique curricular and developmental changes that often serve as obstacles to inclusive science teaching and learning (Brigham et al., 2011). The breadth, depth and complexity of science content dramatically increase during these years as teachers strive to adequately prepare students for the rigours of upper secondary science (Ministry of Education, 2007; Mutch-Jones et al., 2012; Schmidt, Wang, & McKnight, 2005). For instance:

- Greater demands are placed on reasoning and abstract thinking capabilities as students are expected to make sense of invisible phenomena such as atoms, cells or plate tectonics (Ministry of Education, 2007; Mutch-Jones et al., 2012; Rawlins & Walkley, 2016).

- The introduction of new concepts through scientific classroom lectures, discourse (B. A. Brown, 2006) and texts often incorporates a high proportion of unfamiliar and complex vocabulary words (Brigham et al., 2011; Mason & Hedin, 2011; Watt et al., 2014), unknown text structure and reliance on student prior knowledge (Saenz & Fuchs, 2002). Because much of Aotearoa New Zealand science instruction is integrated into wider cross-curricular units of study at the primary level (Rawlins & Walkley, 2016), many students entering secondary do not realise they have previously studied science or engaged in scientific learning, which adds to the difficulty of the transition.
- Students are expected to both understand and responsibly engage in individual and group work that involves multidimensional, hands-on experimentation and/or argumentation (Ministry of Education, 2007; Mutch-Jones et al., 2012; Rawlins & Walkley, 2016).

While the transitional changes pose potential challenges for all middle school and lower secondary science students, students with learning difficulties tend to struggle more than their peers with recalling, acquiring and demonstrating understanding of scientific concepts and skills (Brigham et al., 2011; Mutch-Jones et al., 2012; Özgüç & Cavkaytar, 2015; Watt et al., 2014).

Science inclusion challenges for students with learning difficulties. Research indicates that students with learning difficulties are at risk of falling farther behind peers without difficulties as they advance from primary to secondary school (Mastropieri et al., 2006). Examples of student learning difficulties identified for inclusion within mainstream Aotearoa New Zealand classrooms include: attention-deficit/hyper-activity disorder, autism spectrum disorder, dyslexia, dyspraxia, down syndrome, foetal alcohol syndrome, speech and language disorders, low vision and deaf and hard of hearing (Ministry of Education, 2015a).

Mainstream science classrooms with no adaptions to students' learning difficulties have been shown to result in lower science performance and achievement levels for students with learning difficulties when compared to peers without learning difficulties (Mastropieri et al., 2006; Mutch-Jones et al., 2012). However, research also indicates (Watt, Therrien, Kaldenberg, & Taylor, 2013) that when science "instruction is appropriately presented and modified, students with learning disabilities [difficulties] are very successful at mastering science content" (Brigham et al., 2011, p. 230). Educational experts support differentiating science curriculum to meet the needs of students with learning difficulties (Kevin M. Anderson & Anderson, 2010; Mastropieri et al., 2006; Mutch-Jones et al., 2012; Nolet & McLaughlin, 2005). In-depth explanation of the concept of differentiation and implications for science classroom practice are detailed in the differentiated teaching and learning section later in this chapter.

Exclusion of students with exceptional abilities. Kearney, Bevan-Brown, Haworth, and Riley (2008) argue that students with exceptional abilities, gifts and talents, also run the risk of exclusion in learning opportunities in mainstream classrooms. Riley (2013) observes that in addition to sharing the risks of social and cultural exclusion introduced in this chapter, students with exceptional abilities are particularly susceptible to motivational and cognitive exclusion when "education offerings are below their potential or mismatched to their unique needs, resulting in underachievement" (p. 193). In regular classrooms, "everyone benefits somewhat, but the gifted child benefits somewhat less than others" (Delisle, 2000, p. 2).

Aotearoa New Zealand researcher, Moltzen (2006), agrees, "unfortunately, in many 'inclusive' classrooms, possibly the majority, the gifted and talented remain excluded" (p. 54). A recent study of a national sample of teachers in the United States revealed "more than 80% of teachers do not focus on gifted student learning in their classrooms, focusing instead on the learner who is below grade level expectations" (VanTassel-Baska, 2013, p. 379). Aotearoa New Zealand gifted science students appear to face similar challenges where "given the broad and wide-ranging curriculum and its delivery in inclusive classrooms, it seems the gifted individual gets lost – or has the potential to slip through the cracks" (Riley, 2011, p. 279).

Separate research studies conducted by the Education Review Office (2008) and researchers at Massey University (Bicknell & Riley, 2012; Riley, Bevan-Brown, Bicknell, Carroll-Lind, & Kearney, 2004), found that despite Aotearoa New Zealand gifted students spending the majority of their time in mainstream classrooms, there was little specific support in these classes for gifted learners. Anderson (2000) warns a "failure to recognise and meet the needs of the gifted and talented can result in their boredom, frustration, mediocrity, and even hostility" (p. 6). As previously indicated, exclusion affects a wide demographic range of students, for a gifted child "may identify as Māori, Samoan or any other of our many cultures," (Riley, 2013, p. 193) and/or other ethnic groups identified earlier in this chapter as overrepresented at the bottom of the Aotearoa New Zealand's achievement gap in international science performance (Caygill et al., 2016; Cowie et al., 2011).

Mooij and Smeets (2006) warn that an absence of teachers' responsivity to and accommodation of talented students' needs in the classroom may create a pattern of "forced underachievement" (p. 95), which can impact students' lifelong academic, professional and social enjoyment and success (Colangelo, Assouline, Gross, & Connie Belin & Jacqueline N. Blank International Center for Gifted Education, 2004).

Coxon (2012) and Renzulli (2011) extend this argument, contending that there are wider societal implications for talent development or lack thereof, as well. As stated in the 2012 Programme for International Student Assessment (PISA) Report:

> The rapidly growing demand for highly skilled workers has led to a global competition for talent. High-level skills are critical for creating new knowledge, technologies and innovation and, as such, are key to economic growth and social development. Looking at the top performing students in reading, mathematics and science allows countries to estimate their future talent pool (2013, p. 24).

VanTassel-Baska and MacFarlane (2008) argue that to avoid exclusion within mainstream science classrooms gifted science students need a framework that:

> Provides a foundation for them to become knowledge producers, having internalised the scientific skills such as observation, experimentation, and measurement, as well as having adopted an attitudinal mind-set that views the world through the lens of a scientist, which can be used as a framework for research in all fields (Adams & Pierce, 2014, pp. 562-563).

Table 2.1 highlights the five key components essential to science curriculum that effectively develops these abilities in students with exceptional science talent. Curriculum adjustments include accommodation in content, process and product and emphasise authentic, student-led learning (Adams & Pierce, 2014, pp. 562-563).

Table 2.1: Key Components for Gifted Science Students' Development

• High-level content-based curriculum • Opportunities for laboratory experimentation • Opportunities for interaction with experts (practicing scientists) • Strong emphasis on inquiry processes • Inclusion of science topics that focus on technological application of science in the context of human decision making and social policy

VanTassel-Baska (1998) emphasises it is essential that scientifically talented students understand "what science is and how it works in the real world" (p. 435) including consideration of ethical implications for all scientific research and discovery.

Critical analysis of the identification and modifications for scientifically talented students, reveals, however, an absence of acknowledgement of the need for provisions for scientifically talented students that directly link to values held by non-dominant cultural groups within a school community. For example, giftedness within the Māori culture entails a commitment and "service to Māoridom" (Bevan-Brown, 2011, p. 87). Consequently, there's a need to research for instance, VanTassel-Baska's (1998) applications of science to social policy within the context of whānau, iwi and national needs. This would enable researchers to ascertain if there are strategies and methods that have resulted in increased engagement and/or achievement of non-dominant cultures such as Māori in secondary science.

What is currently lacking in science education research literature is high-quality, evidence-based curriculum resources that enable teachers to incorporate the key gifted components into their classrooms effectively (Adams & Pierce, 2014). Also missing is input from gifted and talented students and their whānau about whether or not key gifted components identified by VanTassel in 1998 still hold value for today's exceptional science learners, including minoritised rangatahi (teenagers).

Furthermore, most research into gifted education has focused on "outcomes of high-ability students in 'homogenous' settings where their academic needs are addressed and 'heterogeneous' settings where their needs are not addressed" (Tomlinson, 2014, p. 299). Results from research addressing issues of diversity and development of talented students in underrepresented non-dominant cultural groups in ability-grouped, gifted secondary science classes (Advanced Placement and International Baccalaureate classes in the United States) (Hertberg-Davis & Callahan, 2008; Kyburg, Hertberg-Davis, & Callahan, 2007) indicated that retention and achievement of minority students in learning environments that responded to diversity through differentiation were higher than in classrooms that adhered to a "one-size-fits-all-approach" (Kyburg et al., 2007, p. 205). The promise of these findings reveals a conspicuous need for research into the effects of responsive differentiation for gifted students of underrepresented, non-dominant, cultural groups in today's ever increasingly diverse mainstream science classrooms.

Differentiation as an Effective Mode of Inclusion

So, what exactly is differentiation, as proposed by advocates for culturally responsive inclusion of both students with learning difficulties and students with exceptional talent? Can science educators realistically include and meet the learning needs of the wide range of pupils that enter their classrooms and laboratories? Many educational theorists and researchers see differentiation as the way forward to addressing diverse students' needs in mainstream classrooms (Kelly M. Anderson, 2007; Borland, 2012; Kanevsky, 2013; Kluth & Danaher, 2014; H. Morgan, 2014; Riley, 2011, 2013; Roy, Guay, & Valois, 2013; Tomlinson et al., 2003; Tomlinson & Imbeau, 2010; VanTassel-Baska, 2012). However, as with inclusion, there are multiple interpretations of what differentiation means and how it should be incorporated in today's diverse classrooms. Tomlinson (1999, 2000, 2003, 2005, 2010, 2014), a leading differentiated teaching and learning expert and proponent, defines differentiation as “modifications in curriculum and instruction necessary to support students with academically diverse learning needs” (Tomlinson, 2014, p. 299).

Maker and Schiever (2010) support Tomlinson’s call for responsive heterogeneous teaching through four dimensions of curriculum modification for students – content, process, product and learning environment:

- content refers to the “concepts, ideas, strategies, images and information” (Maker & Schiever, 2010, p. 67) addressed by teachers and students in the classroom;
- process focuses on how such content is taught and learned, or in Maker and Schiever’s words, the “way educators teach and the ways students use information” (2010, p. 97);
- product incorporates learning outcomes and refers to how students demonstrate what they have learnt such as mode (written assessment, hands-on investigation, debate), context (individual, group) or audience (teachers, peers, experts) and
- learning environment refers to both physical and dynamic components (Maker, Alhusaini, Pease, Zimmerman, & Alamiri, 2015) ranging from room temperature and desk arrangement to how teachers and students interact with each other, including, accepted behaviour, level of classroom volume, safety expectations during hands-on laboratory work and use of digital devices such as phones or tablets.

The interdependent nature of Maker and Schiever’s four curriculum dimensions is represented in Figure 2.1 (modified from Kanevsky, 2013, Chapter 4, p. 5). Kanevsky’s model demonstrates that when an educator chooses to differentiate by making curricular changes such as increasing the complexity of the content, other dimensions of learning are likely to be impacted. For example, higher levels of processing may be needed to understand and apply more complex content. As all learning takes place within a unique setting, the learning environment is represented in this model by the clear background surrounded by a rectangular border, placing the other three dimensions, or elements, within it (Kanevsky, 2011a, 2015). I modified the learning environment component of Kanevsky’s diagram by substituting the word dynamic for psychological as a description to represent developments in literature regarding culturally responsive classroom environments (Cappella, Hwang, Kieffer, & Yates, 2018; Davis, 2017; Glynn, 2015).

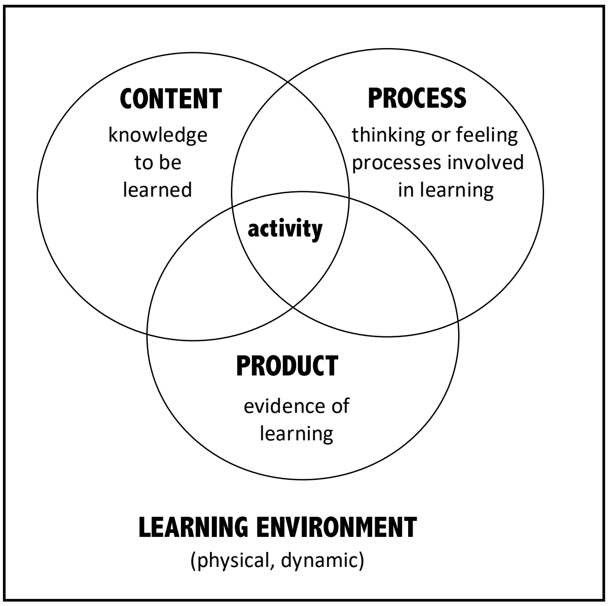

Figure 2.1: Interdependency of Maker and Schiever's 4 dimensions of curriculum modification. Adapted from Kanevsky's *Tool Kit for Learning* (2013, Chapter 4, p. 5) and used with author permission.

Kanevsky (2011) cautions that incorporating Maker and Schiever's four areas of suggested curriculum modification into a classroom, does not, in itself, result in effective differentiated teaching and learning that meets the needs of individual students. In fact, she warns against educators blindly applying the outcomes of any outside research study to their classrooms, declaring the teacher's current individual students as "the most appropriate unit of analysis for differentiating curriculum" (p. 296). Kanevsky (2011) calls on educators to up the ante by incorporating "deferential differentiation" (p. 279). The distinguishing feature of deferential differentiation is that all curriculum modification is rooted in "students' learning preferences by recognizing and including them in the design process" (Kanevsky, 2001, p. 279). Her *Tool Kit for High End Curriculum Differentiation* (2013) evolved from shareholder input (students, educators, parents, school management and resource providers throughout many school districts and classrooms in Canada, the United States, Australia and Aotearoa New Zealand). In it, Kanevsky extended Maker and Schiever's (2010) work by providing teachers, parents and students with accessible tools to recognise pupils needing greater challenge within or across particular content area(s) and to "choose the best curriculum differentiation and learning strategies to make the curriculum more challenging in ways suited to a particular student's characteristics" (Kanevsky, 2013, Ch. 1, p. 1).

Deferential differentiation (Kanevsky, 2011a) is referred to by Tomlinson as defensible differentiation, which includes adaptations in the critical dimensions of “content, process, product, affect, and learning environment in response to student readiness, interests, and learning profiles to ensure appropriate challenge and support for the full range of learners in a classroom” (Tomlinson, 2014, p. 299). Furthermore, Tomlinson (2014) argues that defensible differentiation relies on: (a) a responsive classroom environment; (b) high quality curriculum; (c) authentic teaching, learning and assessment and (d) flexibility in classroom routines. Importantly, differentiation is in response to individual differences. Making defensible differentiation a reality, however, can be quite a challenging task for classroom science teachers, as detailed in the next section of this chapter, which explains the challenges to effective differentiated instruction as observed by researchers, educators or both.

Challenges to differentiated instruction. In this section I introduce factors recently identified by science teachers and researchers as barriers to effective differentiated teaching. I then examine the lack of evidence-based research into and paucity of exemplars for effective science differentiated teaching and learning through an analysis of current science differentiation research. Finally, I evaluate the merit of differentiation critics’ proposal of ability grouping as a viable alternative to differentiation, which then transitions into evidence-based differentiated teaching and learning recommendations for schools and teachers seeking to implement differentiated teaching and learning that is effective yet manageable. Implications for effective professional learning and development in science differentiated teaching and learning for teachers follow.

Teachers identify barriers to science differentiated teaching and learning. While barriers to differentiation in education are well-documented internationally, a review and analysis of the research into the barriers specific to secondary science teaching and learning from the perspectives of science teachers and researchers is the focus of this section of the chapter (Bain & Parkes, 2006; de Jager, 2017; Nicolae, 2014; Tobin & Tippett, 2014). Themes arising from my critique of literature included: (a) teacher proficiency and beliefs in differentiated science content and pedagogy; (b) teacher work-load concerns; (c) school policy and structure issues and (d) community influences, particularly in regards to students and whānau. Specific barriers to science differentiated teaching and learning are grouped by thematic category and summarised for ease of reference in Table 2.2. I then explain each of the barriers more in depth within their research context.

Table 2.2: Differentiated Teaching and Learning Barriers Identified by Teachers and Researchers

Teacher Proficiency & Beliefs	School Policy and Structure
• Disbelief in efficacy of differentiation	• Level of support from leadership
• Content and pedagogy expertise & experience	• Limited resourcing: labs, materials
• Differentiation expertise, experience & efficacy	• Emphasis on assessment results
• Classroom management skills	• Large class sizes
• Fixed-ability view of learners	
• Differentiated emphasis on low-ability learners	**Community: Student/Whānau Influences**
	• Level of whānau support
Teacher Workload	• Whānau socio-economic background
• Increased planning time	• Unpredictable school transport
• Curricular demands	• Irregular student attendance
• Extra-curricular demands	• Second language acquisition for learners
	• Student misbehaviour in class

Teacher proficiency and beliefs were at the heart of Tobin and Tippett's (2014) investigation into perceptions of western Canadian urban elementary teachers (*n* = 5) when planning and implementing differentiation in Grades 3-5 (ages 8-10). This is the only study I could find that applied knowledge gained from differentiation in non-science domains (literacy) to explore teachers' perceptions as they instigated differentiated science instruction. Exit interview responses at the end of teachers' professional development and implementation phases revealed teachers' fears and insecurities about their level of expertise and efficacy in differentiating the science curriculum (22 comments) as shown by the following example, "We're doing a lot of learning and doing at the same time and there's lots of good about that, but then there's a lot of anxious moments with that, too" (Tobin & Tippett, 2014, p. 437). Constrained planning time, curricular requirements, assessment demands and limited resources were also cited as science differentiation barriers. Tobin and Tippett also observed a tendency of these teachers to view and implement differentiation as a tool for meeting the needs of low-ability students, focusing on decreasing, rather than increasing the complexity of the content. Interestingly, teachers also seemed to view student ability as fixed, rather than fluid, across contexts.

De Jager's (2017) investigative work exploring South African secondary school teachers' perspectives (*n* = 262) on implementing differentiated instruction in multicultural public schools (*n* = 27) revealed similar challenges at the secondary level and is the most extensive, current study in this field. Her mixed methods approach to data collection via surveys (*n* = 262) and follow-up interviews (*n* = 20) identified that "inadequate teacher training, large class sizes, workload, undisciplined learners, lack of resources and parental involvement, second language instruction, inadequate support services and socio-economic barriers contribute to the use of teacher-centred methods" (p. 115). While all teachers reported being well informed on what differentiation was, the majority of de Jager's interview participants (*n* = 19) described little to no training in differentiated instruction, stating, "they were not able or sufficiently trained on how to identify learning barriers in their classes and were not always able to apply various teaching methods to accommodate learners' diverse needs" (p. 119). All participants expressed concern over class-size with numbers burgeoning to over 40 students per class with most teachers (*n* = 16) citing classroom management and behaviour as an obstacle to facilitating effective differentiated student group work.

When discussing workload issues, teachers identified the pressures of not only curricular but also extracurricular factors. As many participants hailed from rural schools in areas of poverty, teachers cited a lack of basic resources both on the school site (*n* = 11) and within the community as challenges to differentiation, including unreliable electricity, lack of running water and limited toilet facilities. In addition to posing a potentially unhealthy and possibly unsafe environment, the teachers reported such contributing factors also presented challenges "when creating differentiated activities with a lack of copying facilities, technology support and extra media to assist effective teaching and learning. Furthermore, learners arrived at school tired, hungry and lacking concentration skills, which affects successful learning" (p. 119). Many students with difficulties struggled to arrive at school at all, as transportation and wheelchair access were limited. Teachers (*n* = 17) viewed active whānau engagement in their children's education as essential for student academic success and a school's ability to meet students' individual needs but voiced a concern over a perceived lack of involvement and communication from whānau.

Teachers (*n* = 16) cited the above challenges as compounded even more for students for whom English language was their second or third language, making it difficult for these students to engage in meaningful dialogue with both teachers and peers. Alavinia and Farhady's (2012) research into differentiated teaching and learning with Iranian tertiary students studying English as a foreign language supports the idea that a common language is needed to effectively facilitate and empower peer group learning. Unfortunately, language-learning challenges are compounded during science instruction by the gap that often occurs between scientific classroom discourse (fair testing, controlled experiments) and scientific principles (meticulous attention to detail, detachment of emotion and reason) with students' normative shared discourse and cultural principles, especially among learners of non-dominant cultures (B. A. Brown, 2006; Lemke, 1990; McKinley, 2005; Tolbert, 2015). Yet, as observed by Brown (2006), "developing a thorough understanding of the implications, meanings, and subtexts of communication, what Hymes (1978) called communicative competence” (Brown, 2006, p. 122) is essential if students are to gain full access to participation in the science classroom discourse community.

Lemke (1990) concludes that the “language of science” (p. 172) is not intrinsic to any student’s native language, English or otherwise, but is instead a “foreign register (specialized subset)” (p. 172) developed and mastered through responsive teaching that acknowledges and accommodates student readiness as learners progress in proficiency in the transition from colloquial to scientific explanations. Lemke advocates inclusion of English second language (ESL) learners through not penalising students “for use of alternative dialects or forms of organization and argument, except where the use of formal scientific language is specifically required for good reasons” (p 178). Acknowledging students’ diverse discursive foundations could help prevent the cultural conflict and division within the sciences and science education that many minoritised students may experience (Cowie et al., 2011; McKinley, 2005; Alberto Rodriguez, 2004; Tolbert, 2015).

De Jager (2017) ends her study by concluding that differentiation research into and the development of effective pre-service and in-service differentiated teaching and learning programmes are imperative if teachers are to effectively address and meet today’s diverse learner needs. Findings by Nicolae (2014), however, challenge the notion that experience and training equate effective differentiation in the classroom. Nicolae recently explored the “impact of teachers’ beliefs towards adjusting instruction to students’ variances in readiness, interest, background and learning profile” (p. 426) in Romania, where differentiation is now compulsory.

In addition to the Tobin and Tippet (2014) and de Jager (2017) challenges to differentiated teaching and learning introduced previously, and teacher dissatisfaction over low pay and rising demands, Nicolae (2014) found a key contributor to teachers’ effective implementation of differentiation to be the degree to which teachers believed in the efficacy of differentiation. As such, she calls for adaptions to teacher training and professional development programmes to develop positive teacher attitudes toward a culture of diverse learning and “self-efficiency in differentiated educational practices” (p. 430). M. Mills et al. (2014) agree, concluding that teacher support is essential for worthwhile innovations to become classroom reality. Furthermore, teachers are unlikely to acquire a conviction of the merits of differentiation “when simply compelled to implement reforms” (p. 345) in response to policy makers’ mandates. Mills et al. argue that the complexity of differentiated teaching and learning may require better explication at the policy level as well as stronger support for teachers at the implementation level where “research indicates that effective professional development for science teachers acknowledges teachers' current beliefs and practices, is sustained and context-specific, fosters collaboration, and provides teachers with feedback" (Maeng & Bell, 2015, p. 1086).

In summary, current literature supports the reality that many internal and external obstacles confront teachers as they work to differentiate their teaching in response to student learning needs. As with any complex task, the likelihood of success may be increased when those attempting the challenge receive adequate scaffolding via training and/or support. What is strikingly absent from all studies but Mills et al. (2014) is the inclusion of student voice, which should be a critical contributor in any discussion on the effectiveness of teaching and learning strategies in 21st century classrooms. (It should be noted that Mills et al. do not state how many students were actually interviewed and have based their published article primarily on the perceptions of the principal and four participating teachers.) Despite teachers' identification of parental involvement and communication as essential for effective teaching (Nicolae, 2014) and prior research supporting the engagement of parents in their children's education as being "of paramount importance to the children's academic achievement in mathematics and science" (Meletiou-Mavrotheris & Mavrotheris, 2011, p. 77), no existing research explores the incorporation of parent input in the co-development of differentiated teaching and learning that addresses student needs within a learning community.

Need for more evidence-based research. One of the key criticisms of differentiated instruction is the lack of empirical research into and evidence for the effectiveness of differentiated teaching and learning (Schmoker, 2010; Subban, 2006). For, "in order for teachers to spend the time and energy to develop lessons that will attend to the variety of student learning needs in their classrooms, teachers must believe that their work will result in student success" (Maeng & Bell, 2015, p. 2068). Research into differentiated teaching and learning is indeed an emerging field (Maeng & Bell, 2015; Subban, 2006) with studies developing across education disciplines at primary (Chien, 2012; Goddard, Goddard, & Minjung, 2015), secondary (Martin, 2013; Weber, Johnson, & Tripp, 2013) and tertiary (Subban & Round, 2015; Wan, 2016) levels. A recent examination of peer-reviewed differentiated teaching literature revealed a diverse collection of evolving studies supporting the positive impact differentiation applications are having on education across the globe including:

- improved student achievement in mixed-ability, primary school classrooms in Cyprus where practicing teachers' had participated in on-going, collaborative, professional development in differentiated teaching and learning (Valiandes & Neophytou, 2018);
- increased student cognitive and academic success in middle school algebra instruction in Turkey (Bal, 2016);

- improved creative-thinking skills among Indonesian junior high science students (Zubaidah, Fuad, Mahanal, & Suarsini, 2017);
- enhanced student participation in multi-level secondary music classrooms in Canada (Kizas, 2016);
- increased student engagement and bridging of the achievement gap between urban and rural students in Russia (Kalimullin, Korshunova, & Koinova-Zoellner, 2016) and
- developing efficacy of prospective teachers in Hong Kong (Wan, 2016) and the United States, producing increased student autonomy, engagement and conceptual learning (Jang, Reeve, & Halusic, 2016).

However, analysis of these studies reveals a need for additional research that expands the evidence-based repertoire of exemplars of multiple methods of effective differentiated teaching and learning (Bal, 2016) and ways to assist pre-practice (Jang et al., 2016; Wan, 2016) and existing teachers in developing skills and competence in these areas (Bal, 2016; Kalimullin et al., 2016; Kizas, 2016).

Existing research: Science differentiated teaching and learning in the middle years. In the limited studies that do exist within science classrooms, results suggest that differentiated science instruction may improve both student achievement and engagement (Maeng & Bell, 2015; Mastropieri et al., 2006; Richards & Omdal, 2007; Simpkins, Mastropieri, & Scruggs, 2009; Waters, Smeaton, & Burns, 2004). Simpkins, Mastropieri and Scruggs (2009) conducted a quasi-experimental investigation into the effects of traditional (lectures, discussions, readings, worksheets) versus differentiated (multi-tiered activities in class-wide peer tutoring) science instruction for sixty-one fifth grade science students in the United States of America (Virginia). Of those students, 43 were identified as general education students, 15 as at-risk, and 3 with learning difficulties. Gain score analysis indicated improved results for both achieving and at-risk students. Both teachers and students reported enjoying the experimental differentiated method more than traditional lecture-oriented instruction.

In an earlier quasi-experimental study, Mastropieri et al. (2006) explored the impact of tiered differentiated, peer-meditated, hands-on science instruction as opposed to traditional science instruction (lecture, class notes, worksheets, textbook and laboratory-like activities) in 13 North American inclusive middle school classrooms. Participants included 213 eighth grade students (37 identified with learning challenges, 7 with emotional/behavioural challenges and 35 as English language learners) and 8 general education and/or special education teachers. Results indicated that student performance on pre-post content tests and end-of-year, high-stakes testing were improved through differentiated peer coaching. Students appeared to both better learn the science content and enjoy themselves more under the experimental conditions.

Richards and Omdal's (2007) investigation extended the exploration of the effects of differentiated tiered instruction of science content and process to the secondary level. Five science teachers and the entire freshman cohort (*n* = 388) at an American high school in a western state were involved in this quasi-experimental study. Each teacher taught at least one controlled and one experimental class. Experimental classrooms (*n* = 7; 194 students) utilised a tiered designation assessment to group students by prior astronomy knowledge and skills into three levels of ability: (a) T1 (bottom 10%), (b) T2 (mid-range, 80% of students) and (c) T3 (top 10%). Assessment placement of these students into these categories was reviewed and adjusted by teachers on a case-by-case basis; the students in the experimental classrooms then proceeded to complete tiered work that reflected their placement into the T1-T3 groups.

In the controlled classrooms (*n* = 7; 194 students), all students completed the tiered work designed for the T2 mid-range group. In addition to the tiered designation assessment activity, student achievement was analysed via pre/post instruction assessments and instructional unit materials. All students under the experimental conditions scored equally well or higher than their controlled condition counterparts; the greatest improvement in experimental students arose from the students in the T1 lower pre-unit ability groups. The lack of change among T3 upper ability participants led Richards and Omdal (2007) to contemplate the pedagogical and subject knowledge expertise needed for teachers and/or researchers to differentiate curriculum at levels of depth and complexity required to challenge gifted high school science students; Richards and Omdal were unable to avoid the ceiling effect for these students in their case study. Given the positive response of low-ability students to differentiated teaching and learning, Richards and Omdal concluded that future studies were essential to explore effective differentiation methods and materials for average and high-ability secondary students.

Waters, Smeaton and Burn (2004) also found positive effects of differentiation at the secondary science level through an action-research project in which the teacher-researcher implemented differentiated alternative assessments in three Pennsylvania college preparatory freshmen earth and space classes (*n* = 78 students) over the course of one semester (90 days). All students had the opportunity to select assessment type as well as whether to work individually or in a group. Each student was required to complete five different assessments in a minimum of three formats. Student chosen product assessments included a combination of board games, three-dimensional models, computer presentations, webpages, brochures, newspapers, formal or creative writings and live performances. The teacher-researcher collected and analysed student attitude and behavior data at the end of the semester via surveys and open-ended questionnaires.

Results indicated that the majority of students, but not all, preferred the personalised approach to assessment over standardised multiple-choice tests where “in an attempt to benefit the greatest number of students, the teacher reacted to the study results by retaining procedures or proposing modifications to the system” (pp. 98-99). Adjustments included but were not limited to “increasing specificity in instructions, requiring more details in products, and the retention of choice, personal control in student products, and the use of extended periods of time” (p. 99). No effort to measure achievement or amount of learning (beyond asking students if they felt they had learnt more than when performing a traditional test) occurred in this study. Waters, Smeaton and Burn (2004) acknowledge this in their discussion of limitations and they contend there is need for future investigations to quantify increases in secondary science students’ achievement following differentiation.

In each of the above studies, the onus of differentiated material development was placed on external support from university researchers or classroom practitioner-researchers as part of their graduate work. In a typical classroom setting however, teachers do not have ready access to such support. Maeng and Bell’s (2015) research investigated the differentiated implementation practices of 7 mid-Atlantic United States high school science teachers identified as effective science differentiation instructors by district science coordinators, principals and/or science department leadership. Unlike the previously mentioned studies, no manipulation from outside sources occurred. Teachers were merely asked to open their classrooms for observations and to discuss their work. Participant teaching experience varied from 3 to 26 years. Primary data sources included teacher interviews, classroom observations and teacher planning documents such as lesson plans and instruction materials.

Maeng and Bell’s research was the first to focus on the successful attributes of secondary science professionals’ differentiated school curricula under realistic teaching conditions. Researchers observed instructors to determine the extent that they employed 6 key domains of differentiation including:

- quality curriculum and lesson design;
- planning and response to learner needs;
- instructional practices;
- classroom routines;
- student assessment and
- a positive, supportive learning environment (p. 2084).

Observers also specifically sought evidence demonstrating “participants’ proficiency in employing complex differentiation for content, process, and product” (p. 2084). Without exception, each teacher “scored highest on the quality curriculum and lesson design domain” (p. 2084); all but two scored lowest in formative assessment.

Evidence from 35 classroom observations revealed, “all participants used instructional modifications that required little advance preparation to accommodate differences in students’ interests and learning profile” (Maeng & Bell, 2015, p. 2065). Most of these modifications gave students choice in their “learning environment and how they worked on and completed instructional activities” (p. 2078) such as allowing students to choose their seats, collaborative peer partners, whether to work individually or in groups, the order in which tasks were completed or what materials/resources (such as computers, magazines and/or markers) were used to complete classwork. Very little formative assessment or accommodation of student readiness was observed despite an emphasis of its importance in differentiation literature (Tomlinson et al., 2003). Some teachers also showed evidence of creating authentic learning experiences, connecting student learning to the real world by presenting learning contextually or getting students outside to find earth science examples. Only 4 of the 7 teachers implemented complex instructional strategies, requiring extensive advance preparation, typically in areas of content, process or product. Strikingly absent from all science teachers’ instruction was evidence showing consideration or incorporation of student cultural background when designing or implementing differentiation despite “the ability of culture-based learning” (Maeng & Bell, 2015) to facilitate student academic growth (Bevan-Brown et al., 2015; McKinley, 2005; Tomlinson & Imbeau, 2010).

Because only 1 of the 7 teachers identified by their schools as excellent differentiators utilised a breadth of science classroom differentiation strategies, Maeng and Bell (2015) infer a need for on-going in-service professional development in differentiated teaching and learning for science teachers that is science specific. They suggest key components of such professional learning to be time and opportunities for teachers to (a) reflect and share existing excellent science differentiation models, (b) collaboratively plan new resources and (c) practice new techniques. Maeng and Bell also call for future studies exploring outcomes of such in-service professional development training as determining student behaviours toward differentiated teaching and learning in the sciences.

In a subsequent qualitative study, Maeng (2017) further explored the differentiated "beliefs and practices" (p. 1075) of the participating teacher who had demonstrated the greatest competence in differentiated science teaching and learning during the 2015 investigation. 37.5 hours of classroom observations and 3 hours of semi-structured interviewing in secondary biology (8 students) and ecology classes (17 students) indicated that technology (e.g. the use of student clickers) was an integral component for that teacher in maintaining feasible, on-going formative assessment that guided teacher differentiated planning and implementation responsive to students' needs. Results suggested that assessing and responding to student readiness may present the most challenging aspect of effective science classroom differentiation for teachers. Again, as with Maeng and Bell's previous study, the exclusion of student voice necessitates future research examining "differentiated science instruction from a student perspective including the student perceptions of differentiated instruction and student outcomes in differentiated classrooms" (p. 1096).

Reflection upon and analysis of the limited existing science differentiated teaching and learning research of the middle years of intermediate and early secondary school reveals that science differentiation appears to have the potential to positively affect student engagement and achievement, both within class and on end of the year performance assessments, particularly among learners with learning difficulties. However, even secondary teachers identified by school communities as excellent differentiators struggled to implement a breadth of differentiated instruction strategies in their classrooms. Particularly lacking were complex science differentiated teaching and learning approaches, assessment of and accommodation in response to varying student readiness and incorporation of student cultural background.

The failure to address student prior knowledge and skills readiness of high-achieving and talented students is especially concerning given Richards and Omdal's (2007) observation of a lack of growth of top tier science students in differentiated courses and the risks of 'forced underachievement' to students' individual lives and society's innovative capacity introduced earlier in this chapter. The absence of cultural responsivity in science education literature indicates a need for culturally responsive research to explore ways to confront the perpetuation of the achievement gap in the sciences between dominant and non-dominant cultures to prevent further marginalisation of students including those of Indigenous Māori descent. As diversity in the science classroom continues to increase (Mastropieri & Scruggs, 2013), so, too, does the growing need for on-going educational research that identifies and validates effective, efficient, culturally responsive, differentiated teaching and learning strategies and materials that provide all students with enjoyable and appropriately challenging experiences. Such strategies and materials must be feasible for both new and experienced teachers to implement (Scruggs, Mastropieri, & McDuffie, 2007).

Delisle, a staunch critic of differentiation and advocate of acceleration for gifted and talented learners in both peer-reviewed (1999a, 1999b, 2000, 2002, 2003) and non-peer reviewed literature (2015a, 2015b, 2015c), questions whether or not any amount of research will provide teachers with exemplars of differentiated teaching and learning capable of effectively responding to all students' needs. Delisle promotes between-class ability grouping (cross-grouping) within homogenous classrooms as a more effective strategy for meeting talented students' needs. The next section of this chapter introduces the argument for cross-grouping and analyses its legitimacy by reviewing recent research findings on ability grouping both internationally and within Aotearoa New Zealand. This analysis leads into a description of alternative, evidence-based suggestions for teachers aiming to improve their differentiated teaching and learning practice.

Ability grouping as an alternative to differentiation. At the time that I conducted this research Delisle was the only voice I could find in current literature arguing that differentiation was an ineffective teaching strategy, declaring it be "a failure, a farce, and the ultimate educational joke played on countless educators and students" (2015c, p. 36). Although he supports some underlying premises of differentiation such as probing and responding to students' current knowledge and understanding, promoting variety of product and enhancing depth and complexity, he declares that the diversity of modern heterogeneous classrooms presents an insurmountable workload for teachers trying to differentiate. That, combined with a confusing array of multiple interpretations of what differentiated teaching and learning is, has led him to conclude that "differentiation in practice is harder to implement in a heterogeneous classroom than it is to juggle with one arm tied behind your back" (p. 36).

Delisle's (2015c) alternative solution, however, to create homogenous classes for gifted students in which "students of similar abilities [are] placed in classes with other students whose learning needs paralleled their own" (p. 36), is critiqued by researchers and practicing educators alike as similarly unrealistic, for any class composed of more than one student has diversity of interests and learning needs (McTighe, 2015; Nicolae, 2014; Robb & Bucci, 2015; Smit & Humpert, 2012; Tomlinson, 2015; Wiggins, 2015). If anything, the level of diversity is increasing in the classroom (de Jager, 2017; Messiou & Ainscow, 2015), as well as acknowledgement of the importance of culturally responsive education both within Aotearoa New Zealand (Bevan-Brown et al., 2015; Cowie et al., 2011; Habib, Densmore-James, & Macfarlane, 2013; McKinley, 2005; Tolbert, 2015) and internationally (Ebersole et al., 2016; Habib et al., 2013; Habli, 2015; Hudiburg, Mascher, Sagehorn, & Stidham, 2015; P. Sullivan, Jorgensen, Boaler, & Lerman, 2013).

While educational research in the United Kingdom indicates Delisle's (2015c) proposed between-class ability grouping (cross-grouping) has some benefit for high-ability students, it also shows students in low-ability groupings do worse, contributing to a widening achievement gap, negative student attitudes and decreased learner motivation toward school (Duckworth, Akerman, Gutman, & Vorhaus, 2009; Kutnick, Sebba, Blatchford, Galton, & Thorp, 2005). In fact, as reported by Hornby and Witte (2014), the National Association of School of Psychologists in the United States has taken a stance against ability grouping due its disproportionate effects on minority, economically disadvantaged and low-achieving students with low levels of ability.

Tomlinson (2015c) voiced similar concerns in a recent rebuttal to Delisle's (2015c) criticisms. She references the work of educator Haberman (1998, 1999, 2007) asserting that low-track classes support a "pedagogy of poverty" (2015c, para 11) in which students, typically from low-income backgrounds, receive low-quality learning, and as a result, perpetuate a cycle of poverty for these students as adults. Anthony and Hunter (2016) identify similar risks within Aotearoa New Zealand, arguing that ability grouping further marginalises students already disadvantaged within today's education system, perpetuating exclusion rather than inclusion of at-risk learners. In addition, a new meta-analysis (Steenbergen-Hu, Makel, & Olszewski-Kubilius, 2016) of 100 years of the effect of ability grouping on K-12 students' academic achievement in the United States revealed no benefits for high, medium or low students with between-class grouping ($0.04 \leq g \leq 0.06$). Only in within-class grouping ($0.19 \leq g \leq 0.30$), cross-grade grouping ($g = 0.26$) or special grouping (pull out classes: $g = 0.37$) did gifted students significantly outperform non-accelerated peers.

Here in Aotearoa New Zealand, where Delisle's style of between-class grouping by ability to create more academically homogenous classrooms is present in some schools (Hornby & Witte, 2014; Hornby, Witte, & Mitchell, 2011), similar concerns arise. In a study investigating the student grouping practices of 15 Christchurch high schools (encompassing a breadth of social, economic and demographic diversity), through interviews with school leadership, Hornby and Witte (2014) found 14 high schools incorporated a version of cross-grouping, typically streamed by high ability, low ability (special educational needs) and in between ability. Perceived positive effects and advantages of between-class ability grouping were reported for exceptional students (increased extension and challenge) and those with learning difficulties (extra literacy and numeracy support in smaller classes). However, results indicated no benefits for Māori, Pasifika, ESL or average students. Analysis of this study reveals that markedly absent from this research was the inclusion of teacher, student and whānau voice, despite the potential of ability grouping to impact these stakeholders' lives the most. Additionally, all results were derived from anecdotal or descriptive interview responses of school leadership without support from empirical evidence of classroom observations or achievement data.

Indeed, Anthony and Hunter's (2016) reflection on recent research into ability grouping within mathematics at both the primary (Golds, 2014) and secondary level (Hornby & Witte, 2014) has indicated ability grouping in most Aotearoa New Zealand schools, including cross-grouping, is based on the personal belief of school leadership rather than evidence-based research. Additionally, the majority of benefits described by school leadership interviewees were advantages for schools and/or teachers, such as better use of school resources and teacher strengths/interests. The majority of the disadvantages reported the negative impact for students including:

- lowered student expectations for all but high-ability students,
- risks of stigmatisation and lack of academic peer role model interaction for low-ability students and
- reduced differentiation due to teacher assumption that the cross-grouped classes contained students of homogenous ability (Hornby & Witte, 2014).

Based on pre/post survey evidence gathered from post-graduate level professional development research with Aotearoa New Zealand primary mathematics teachers, Anthony and Hunter (2016) advocate that "flexible heterogeneous grouping practices aligned with collaborative problem-solving learning environments" (p. 1) provide more equitable, dynamic and fruitful learning opportunities for diverse students of all abilities than attempts at ability grouping.

Again, both Hornby and White's (2014) study and Anthony and Hunter's (2016) research are purely descriptive, lacking empirical quantitative evidence and the inclusion of student and whānau stakeholder input. If heterogeneous grouping practices truly foster more productive learning environments, then more educational research is needed to explore how to best do this in other subject areas beyond mathematics such as science.

Critique of current educational research into cross-grouping indicates that ability grouping may potentially increase the academic achievement for gifted and talented students. However, analysis also reveals that ability grouping tends to decrease performance and motivation of low-ability students including those marginalised by culture. Other strategies such as flexible heterogeneous grouping practices may better serve the continuum of student need present in modern day secondary science classrooms. The next section of this chapter discusses recommendations for manageable differentiated teaching and learning that arose from my examination of literature in differentiation alternatives to ability grouping.

Differentiation Recommendations for Practice

Literature indicates that putting differentiation into practice may require: (a) the incorporation of teacher and student input through evidence-based prioritisation and online analysis tools and (b) an acknowledgement that meeting all needs of each learner daily is unrealistic and detrimental to teachers and students alike, as explained next.

Incorporating teacher and student input. Differentiated education researchers agree that input from both teachers and students is a crucial component to effective differentiation that is both manageable for teachers as well as relevant and responsive to learners' needs (Hopgood & Ormsby, 2011; Kanevsky, 2011a; Mastropieri et al., 2006; Tomlinson, 2015). Hopgood and Ormsby (2011) refer to this two-dimensional concept as "Differentiation in 2-D" (para. 18), stating:

> Differentiating instruction involves manipulating the teacher-dependent dimensions [content, process, product, environment] – those variables over which teachers have control. But differentiating instruction effectively requires manipulating those variables with attention to the student-dependent dimension [readiness, interest, learning profiles] – the variables over which teachers have no control, but that make each student unique (para. 20).

The integration of 2-D teacher and student voice within the differentiated teaching and learning planning and implementation process enables educators to prioritise the plethora of differentiation choices by popularity, reducing the options "to a manageable few, making this [differentiation] endeavour much more feasible and attractive" (Kanevsky, 2011a). Hopgood and Ormsby (2011) promote technology through online surveys such as Survey Monkey as a viable time-saving option for educators when determining the student-dependent dimension, allowing instructors to "create, host, and administer a learning inventory, and then easily analyze the results – all without students feeling put on the spot" (para. 23).

Kanevsky (2013) developed her *Tool Kit for High End Curriculum Differentiation* in response to the lack of evidence-based tools available to teachers, students and whānau for effectively prioritising Maker and Schiever's (2010) differentiated teaching and learning components to meet the needs of exceptional students for subject-specific content areas (sciences, language arts, mathematics) within the classroom. In doing so, she aimed to enable key stakeholders to better choose curriculum differentiation and learning strategies that effectively challenged gifted and talented students through addressing learners' strengths, interests and preferences. Kanevsky's (2011) *Possibilities for Learning (P4L): A Learning Preference Survey* provides students with the opportunity to rate their most and least favoured settings for learning environment on a 5-point scale of strongly agree to strongly disagree. Questions address:

- learning environment (46 questions),
- content (20 questions),
- process (29 questions) and
- product (16 questions) within favourite school subject(s).

P4L is not intended to identify student learning styles, but rather preferred learning possibilities. Teachers are then able to apply survey findings to classroom planning and lesson variation that is responsive to class and student needs. Kanevsky's (2011) investigation into the applications of the P4L survey into the learning preferences of 646 grade 3-8 students in their favourite subject (416 identified as gifted, 230 not identified as gifted), found "substantial commonalities" (p. 296) in learning preferences for both groups of students, such as self-pacing and choice, allowing teachers of participating students to respond by prioritising their differentiated planning accordingly.

Individualised differentiation unrealistic and detrimental for teachers and students. Despite advocacy of incorporating student voice through responses derived from the P4L in selecting appropriate differentiated teaching and learning classroom components, Kanevsky (2011) warns schools and teachers against the pressure to individualise learning programmes to meet the needs of all individual students every day. She asserts that students do not need to have each lesson catered to their current individual preferences, rather, "students need to develop a broad repertoire of learning strategies, including some they don't like, that they can draw on in the future" (p. 296). Kanevsky encourages facilitating student self-management and interpersonal skills such as persistence during unfavourable tasks, resilience among challenge, accommodation for and appreciation of others' differing preferences. Such suggestions align with the New Zealand Curriculum's (Ministry of Education, 2007) Key Competencies of 'managing self' and 'relating to others'.

Mills et al.'s (2014) recent case study exploring the way that Red Point High School (Australia) teachers responded to the Queensland Teaching and Learning Audit mandate to differentiate teaching and learning, supports Kanevsky's (2011) conclusions. Through collection and analysis of classroom observations, interactions with teachers during workshops and stakeholder interviews (teachers, management, Indigenous liaison officers and students), Mills et al. concluded that:

> students from marginalised backgrounds will benefit from having their cultures valued in the classroom, and that those from more privileged backgrounds will also reap the

> benefits from pedagogical practices that expose them to rich and diverse forms of knowledge and understandings about the world (p. 344).

Mills et al. contend that effective differentiation is incorporated over time with consideration of teacher workload. An individualised approach to differentiation, they argue, presents an impossibility for secondary teachers instructing up to six different classes a day. Furthermore, it promotes the erroneous perception of learning difficulties or disadvantage "as an individual problem rather than as a problem created through systemic or structurally driven inequities and injustices" (p. 344). Educators and overall schooling systems then run the risk of washing out of pedagogical consideration societal oppressions of "gender, race, ethnicity, class, sexuality, and age" (p. 344). To do so within early secondary science classrooms would potentially further marginalise students with learning difficulties or those of minoritised cultural groups already struggling with the increased expectations of rigour and complexity of science process and content.

Rethinking Teachers' Professional Learning and Development

So how do we best equip teachers to foster reflective science practice that differentiates for all students? Guskey and Yoon (2008) observe that "in the history of education, no improvement effort has ever succeeded in the absence of thoughtfully planned and well-implemented professional development" (p. 497). My analysis of current literature revealed a wealth of diversity in the definitions of, suggestions for and implementation of teacher professional development. However, all development initiatives had a common underlying key principle, "the understanding that professional development is about teachers learning, learning how to learn, and transforming their knowledge into practice for the benefit of their students' growth" (Avalos, 2011, p. 10).

Teachers as active contributors. The thinking behind and strategies employed for teacher development have shifted gradually over the past twenty years (Avalos, 2011; Bleicher, 2014; Messiou & Ainscow, 2015). Traditional professional development emphasises an "involvement in external courses" (Messiou & Ainscow, 2015, p. 247) or 'top-down' legislation (Butler & Schnellert, 2012). However, as Osterman and Kottkamp (2004) state:

> Too often, it [professional development] is detached from the real concerns of educators and fails to build on their experience and knowledge, relying instead on externally generated information. Consisting of ideas, information, skills, perspectives, facts or ways of knowing, this specialised, firmly founded scientific and standardised knowledge is assumed to be truth and can then be given to others. In the traditional model of professional development, the formal knowledge base is both the beginning and end of the process (p. 19).

Most traditional ‘top-down’ strategies and initiatives “fail to recognize the knowledge and expertise of educators, [and] underestimate the importance of teachers’ adapting practices to meet local needs” (Butler, Schnellert, & MacNeil, 2015, p. 1206) undermining both teacher morale and vested interest in educational innovation (Barnett, 2004; Butler & Schnellert, 2012; Ryan & Weinstein, 2009). This is particularly disconcerting given the potential of evidence-based contextual classroom practice to lead responsive and effective educational change (Butler et al., 2015; Hopkins, Stringfield, Harris, Stoll, & Mackay, 2014; Stein & Coburn, 2008).

Messiou and Ainscow (2015) argue that teachers “need more effective forms of professional development to address the challenges they face” (Messiou & Ainscow, 2015, p. 246). Today, researchers and practitioners alike recognise that “the field of professional development is moving towards the notion of professional learning, highlighting the active learning role that teachers play in changing their knowledge bases, beliefs and practice” (Bleicher, 2014, p. 802). This change adheres to Schon’s (1983, 1991) model of reflective practice, which “shifts attention back to the practitioner and assigns a conspicuous, explicit, and central role to experiential knowledge” (Osterman & Kottkamp, 2004, p. 19). The notion of incorporating practitioner voice in professional learning decisions and direction is based on growing evidence that supports the reality that:

> Teacher professional learning is a complex process, which requires cognitive and emotional involvement of teachers individually and collectively, the capacity and willingness to examine where each one stands in terms of convictions and beliefs and the perusal and enactment of appropriate alternatives for improvement or change (Avalos, 2011, p. 10).

Professional development is most effective when it makes use of the expertise that already exists within a school’s status quo (Ainscow, Dyson, Goldrick, & West, 2012). As Darling-Hammond et al. (2009) suggest, it should align with existing “school improvement and priorities and goals” (p. 9).

Contributing to a shift away from top-down professional development toward practitioner-centred, experiential professional learning initiatives are “changing views regarding how practice develops amongst those who work in fields where there are high levels of unpredictability and where, as a result, responses must involve flexibility” (Messiou & Ainscow, 2015, p. 247). Even the language used within the teaching profession is altering to reflect this move toward teachers as active contributors to professional growth, with terms such as ‘in-service training’ and ‘staff development’ being replaced with ‘professional development’ and ‘professional learning’ (Bleicher, 2014; Jaipal & Figg, 2011; Messiou & Ainscow, 2015).

Avalos (2011), in an analysis of teacher professional learning literature over the past decade, concludes that:

> The instruments used to trigger development also depend on the objectives and needs of teachers as well as of their students. Not every form of professional development, even those with the greatest evidence of positive impact, is of itself relevant to all teachers. There is thus a constant need to study, experiment, discuss and reflect in dealing with teacher professional development on the interacting links and influences of the history and traditions of groups of teachers, the educational needs of their student populations, the expectations of their education systems, teachers' working conditions and the opportunities to learn that are open to them (p. 10).

Messiou and Ainscow (2015) state that effective teacher development should:

- occur in context, primarily in classrooms;
- connect to and build on existing expertise within the school;
- be collaborative, and develop a 'language of practice' as teachers articulate what is happening in their classrooms through reflecting, "planning together, sharing ideas and resources, and having opportunities to observe one another working" (249) and
- be evidence-based.

As such, if future professional learning and development into differentiated teaching and learning is to be effective and sustainable in its ability to promote responsive teaching and learning that addresses students' needs within diverse classrooms, it needs to build on existing teacher expertise, allowing time for on-going collaborative interactions among teachers rooted in authentic classroom practice. Further research is currently needed in collaborative planning of science differentiated teaching and learning to provide schools with evidence-based exemplars of how to do this well, particularly research that engages communities in partnership with teachers and schools in the quest to effectively meet the unique needs of current students.

Engaging communities in science education reform. Messiou and Ainscow (2015), in a three-year collaborative action research study in three European countries exploring ways to "support teachers in developing inclusive classroom practices by engaging with the views of students" (p. 246), found student voice to be an excellent "catalyst for the development of new [teacher professional development] thinking and practices in response to learner differences" (p. 246). They found that students' "hidden voices" (p. 251), which are often overlooked or ignored in educational research and teacher professional development directives, can be an effective contributor to improving teaching and learning in schools.

Educational research also indicates that there is a strong positive connection between whānau involvement and children's attitudes toward and success in school, both internationally and within Aotearoa New Zealand (Bevan-Brown, 2011; B. S. Bloom & Sosniak, 1985; Honigsfeld

& Cohan, 2010; Wu, 2008). Of particular significance to this research is the observation that whānau possess essential information about their children's strengths, weaknesses and interests that might not be evident to those within the school setting. Such whānau knowledge can be crucial to meeting the needs of both students who struggle with learning difficulties as well as highly able learners in all cultural groups, but particularly marginalised groups including Māori and Pasifika (Bevan-Brown, 2011; Bevan-Brown et al., 2015; Lee & Olszewski-Kubilius, 2006; McBee, Shaunessy, & Matthews, 2012), who, as explained earlier in this chapter, tend to be over-represented at the bottom of the science achievement gap in Aotearoa New Zealand (Caygill et al., 2016; Cowie et al., 2011).

McKinley (2005) notes an absence of research literature both internationally and within Aotearoa New Zealand that engages Indigenous communities in science education despite the potential of local Indigenous communities to positively transform students' science learning. As such, she urgently argues for future science education research to explore schools' collaboration and consultation with Indigenous communities "over what science education they [communities] want for their children, how best they as parents [whānau] can support this, and how this can be achieved together" (p. 237). Science education research that engages Māori communities in partnership and participation while still protecting Indigenous identity and rights aligns well with the principles of Aotearoa New Zealand's founding document, Te Tiriti o Waitangi and is supported by current research into key contributing factors Māori secondary student success (Berryman, 2017; Berryman & Eley, 2017; Webber, 2012, 2015). Furthermore, Berryman and Eley (2017) identify home, school and community collaboration as one of three critical contexts for changing the status quo of Māori academic underachievement (the other two being culturally responsive pedagogy and adaptive expertise driving professional acts).

In the next section of this chapter I introduce Te Tiriti o Waitangi history, principles and bicultural influence on both past and present Aotearoa New Zealand society followed by an explanation of implications for culturally responsive Indigenous Māori education and social research. I then transition into the implications of this literature review for my mixed methods action research, concluding the chapter with the purpose of my study and corresponding research questions.

Cultural Responsiveness within Aotearoa New Zealand

While bicultural relations between Māori and early Pākehā (European) traders, whalers, sealers and settlers had been established across a range of varying degrees, Te Tiriti o Waitangi formally established a framework in 1840 for biculturalism and reciprocal, cultural responsiveness; nonetheless, the extent to which the broad implications of the Treaty, the Treaty principles and the Treaty's intent have been realised in Aotearoa New Zealand is contentious. It is only since the final quarter of the last [19th] century that the concepts of biculturalism and reciprocity as espoused by Te Tiriti have become entrenched into legislation, for example, The Treaty of Waitangi Act 1975, the Resource Management Act 1991, the Education Act 1989 and the Local Government Act 2002, where the principles of Te Tiriti underpin the broad framework that guides Aotearoa New Zealand's obligations to all cultures and ethnicities present in Aotearoa New Zealand today.

Te Tiriti o Waitangi. Aotearoa New Zealand is founded upon Te Tiriti o Waitangi, the agreement between the British Crown and Māori rangatira (chiefs) representing their respective iwi (tribes). Te Tiriti o Waitangi was developed in response to unruly British settler behaviour, growing tensions between armed (guns) and unarmed iwi, escalating unease between iwi and settlers over land ownership, and pressing threats from other colonial powers such as France expanding their realm in the Pacific with Aotearoa New Zealand being strategically placed, albeit a long way away from the homeland – Great Britain (Graham, 2002). The political compact, written in both English and te reo Māori with conflicting meanings, consisted of three articles that identified its intent, and can be encapsulated as the 'spirit of the Treaty' or what is contemporarily summed up as key principles on which British governance (rule), Māori sovereignty and the nation state of Aotearoa New Zealand were to be built. In the English version of Te Tiriti, Māori gained the Queen's protection and rights as British subjects, surrendered sovereignty to Britain and agreed to exclusive land sales to the Crown (limiting the colonial influence of private entrepreneurs and other European powers) in exchange for full, undisturbed ownership of property. In the Māori version, Māori yielded governance rather than sovereignty to the Queen, land sales were not defined as exclusive to the Crown and rangatira retained tino rangatiratanga (chieftainship or full authority) over taonga (treasures) that included both tangible (land, water, forests) and intangible (language, cultural values and traditions) riches (Ministry for Culture and Heritage, 2016; Orange, 2012).

Differences in understanding Te Tiriti o Waitangi Māori and English texts contributed to debate at the time of its signing and to disputes and controversies that continued through to the 20th century and up to today. Both the application of the Treaty's principles to Aotearoa New Zealand government policy and the status of Te Tiriti o Waitangi within Aotearoa New Zealand society have fluctuated greatly since 1840. It was not until the 1970's, after the establishment of the Waitangi Tribunal through the 1975 Treaty of Waitangi Act, and in response to Māori protests, that the principles of Te Tiriti o Waitangi were identified by various entities including the Crown, and awareness of its meaning for modern Aotearoa New Zealand began to grow

(Hayward, 2017; Lourie, 2016; Ministry for Culture and Heritage, 2016). In 1985, the Waitangi Tribunal was granted jurisdiction to investigate alleged retrospective Tiriti breaches dating back to its signing in 1840 (Ministry for Culture and Heritage, 2015) of which over 2000 claims have been submitted (Ministry for Culture and Heritage, 2016). Recent successive governments continue to recognise “the significance of the Treaty in the life of the nation” (Ministry for Culture and Heritage, 2016, p. 2 para. 9) and while Te Tiriti o Waitangi remains contentious for a large proportion of the country (Lock, 2017), there are positive initiatives being implemented at a macro level of society such as *Ka Hikitia – Accelerating Success: The Māori Education Strategy* (Ministry of Education, 2013). This Ministry of Education strategy was designed to enable “Māori to enjoy and achieve educational success as Māori” (2013, p. 6) and it emphasises bicultural partnership as the first of five key principles that effective schools must uphold and demonstrate.

Biculturalism in society. Although Te Tiriti o Waitangi established a bicultural and social context within Aotearoa New Zealand long ago, Lourie (2016) credits the Fourth Labour Government as the initiator of bicultural government policies in 1984, “as an acknowledgement of, and response to, the historical injustices suffered by Māori people as a consequence of colonisation” (p. 638) and decades of monocultural policies. While bicultural policies and legislation that recognised Te Tiriti o Waitangi became more prominent at this time, it was the ‘Third’ Labour Government’s Minister of Māori Affairs, Matiu Rata, who was the architect of the 1975 Treaty of Waitangi Act and other significant policies and legislation that provided the foundations for these developments in the mid-1980s. Belich (1996, 2001) identifies this recognition of the Treaty’s significance and emergence of biculturalism in national discourse as “one of the most important social and political developments in New Zealand in the latter part of the twentieth century” (Lourie, 2016, p. 639).

Lourie (2016) defines biculturalism in Aotearoa New Zealand today to be “the conceptualisation of two ethnically and culturally different peoples (Māori and Pākehā/European) in a relationship of social and political partnership” (p. 638). She observes it is very closely related to a form of multiculturalism identified by Kymlicka (1995) and Colombo (2015) that is characterised by claims of recognition for “indigenous and sub-state national groups” (Lourie, 2016, p. 638). Multiculturalism proponents (Kymlicka, 1995; Song, 2010) argue that “proper recognition of cultural diversity is a necessary step towards revaluing previously disrespected identities and changing dominant patterns of representation and communication that marginalise certain groups” (Lourie, 2016, p. 638) including Indigenous people groups such as Native Americans, Greenland Inuit, Aboriginal Australians or Māori (Lourie, 2016). Extending on Kymlicka’s work, Justice E. Durie (2005) argued that Aotearoa New Zealand should no longer view biculturalism and multiculturalism "as mutually exclusive" (p.1) but, rather, recognise their ability to address different issues: biculturalism as "the relationship between the state's founding cultures where there is more than one" (p. 1) and multiculturalism as "the acceptance of cultural differences generally" (p. 1). Both internationally and within Aotearoa New Zealand, multicultural Indigenous policies typically address issues of past injustice, on-going inequality (Colombo, 2015; Lourie, 2016), and protection of taonga such as Indigenous languages (Lourie, 2016; S. May, 2012).

Despite the connections in both philosophy and practice of Aotearoa New Zealand's constructs of biculturalism and multiculturalism, Māori have historically, and continue to, reject the 'multi' terminology (Lourie, 2016; S. May, 2002; J. Smith, 2010). A justification of the pro-bicultural stance is provided in the following excerpt from the Report of the Waitangi Tribunal Report on the Te Reo Māori Claim (1986):

> We do not accept that the Māori is just another one of a number of ethnic groups in our community. It must be remembered that of all minority groups the Māori alone is party to a solemn treaty made with the Crown. None of the other migrant groups who have come to live in this country in recent years can claim the rights that were given to the Māori people by the Treaty of Waitangi. Because of the Treaty, Māori New Zealanders stand on a special footing reinforcing, if reinforcement be needed, their historical position as the original inhabitants, the tangata whenua of New Zealand (pp. 27-28).

Māori concerns over abandoning biculturalism are justified by experiences of Indigenous Aboriginal people overseas. In countries such as Australia and Canada, the Aboriginal people report that multicultural governmental policies are often created by immigrants for migrants with little to no recognition of Indigenous people as the original inhabitants of the land (Irwin, Rogers, & Farrell, 1999; J. Smith, 2010). The Indigenous peoples describe their status under such policies, including public education (Irwin et al., 1999), as reduced to just one of many small minority groups, threatening the survival of their heritage and culture (Fleras & Elliot, 1992; J. Smith, 2010).

Lourie (2016) observes that while Aotearoa New Zealand's conceptualisation of biculturalism may go further than many countries in recognising and accommodating Indigenous culture, it remains a complex and contested concept. Little consensus for what the Māori and Pākehā partnership means in theory or practice exists (Fleras & Spoonley, 1999; Lourie, 2016; D. O'Sullivan, 2007). Critics argue that biculturalism tends to disregard Aotearoa New Zealand's increasing multi-ethnic population, excluding Pasifika, Asian and other non-British New Zealanders from discourses of national identity (Bromell, 2008; Lourie, 2016). As an American immigrant to New Zealand, I often find myself ticking the 'other' box for ethnicity on government documents for 'New Zealand European', which does not accurately describe my ancestry. Rata (2014, p. 39) observes:

> A politics that recognises categories of people based on their genetic heritage is non-universal because it includes some and excludes others . . . Progressive politics, with its goals of equality and justice is, by definition, the destruction of traditional forms of social organisation that award status on the grounds of birth and accord privilege or low status to that birth ascription.

It is unlikely that the tensions between biculturalism and multiculturalism will be resolved in the near future as diversity in Aotearoa New Zealand continues to increase (Lourie, 2016). Nonetheless, as previously mentioned, Te Tiriti o Waitangi's significance to education is demonstrated in *Ka Hikitia's* first principle of partnership or bicultural integration (Ministry of Education, 2013). Similarly, the Aotearoa New Zealand National Curriculum (Ministry of Education, 2007) promotes partnership, participation and protection for Treaty partners. A more in-depth description of these principles and their influence on Aotearoa New Zealand education and social research ensues in the following subsection of this chapter.

Biculturalism within education. Educators in Aotearoa New Zealand are challenged today to implement biculturalism as espoused through the principles and spirit of Te Tiriti o Waitangi while responding to and meeting the interests and needs of unique individual students in diverse classroom settings (Jenkin, 2014; Ministry of Education, 2007). Glynn (2015) asserts that it is essential that Aotearoa New Zealand educators recognise and create opportunities for Māori to exercise their tino rangatiratanga within mainstream education, "defin[ing], protect[ing] and control[ing] . . . pedagogy and epistemology, what counts as knowledge, and how that knowledge is to be preserved, transmitted, used and evaluated" (p. 2013). The Aotearoa New Zealand Curriculum (Ministry of Education, 2007) identifies Te Tiriti o Waitangi as one of eight principles that should "underpin all school decision making" (p. 9), it declares Te Tiriti as an integral aspect of the curriculum's vision, in which young people "work together to create an Aotearoa New Zealand in which Māori and Pākehā recognise each other as full Te Tiriti o Waitangi partners, and in which all cultures are valued for the contributions they bring" (p. 8).

While noble, this vision statement is quite complex. First, the term Pākehā, although commonly used in Aotearoa New Zealand since at least 1815, has had numerous meanings including British immigrant, white New Zealander, or anyone of non-Māori descent (Ranford, 2000). Because of the ambiguity of meanings and potential exclusions that are sometimes linked with the term Pākehā, I have chosen to use the terms Māori and non-Māori from this point forward in the literature review and subsequent chapters detailing methodology, data collection, analysis and findings. Secondly, successful Te Tiriti o Waitangi integration into education is further compounded by the “reality of primarily monolingual and monocultural paradigms within the school system” (Gordon-Burns & Campbell, 2014, p. 20).

In response to schools still struggling with effectively integrating Te Tiriti o Waitangi intentions in the 21st century, the Ministry of Education released a Te Kete Ipurangi (TKI) Curriculum Update (January 2012) to support “schools in understanding and enacting the curriculum principle of the Treaty of Waitangi” (p. 1). The Ministry of Education suggested that schools focus on three distinct principles, taken from the 1988 Royal Commission on Social Policy:

- partnership – schools collaboratively working to incorporate the knowledge and expertise of local Māori and non-Māori families, whānau, iwi and other community members to “develop, implement, and review policies, practices, and procedures” (p. 2) that benefit all learners;
- participation – “equality of opportunity and outcomes” (p. 4) emphasising “informed civic participation” (p. 4). The Ministry of Education declared, “when this principle is realised, the aspirations and views of Māori students, and of their parents, whānau, and communities are apparent in school and classroom planning” (p. 4) and
- protection – “actively protecting Māori knowledge, interests, values, and other taonga” (p. 3) providing all students with the opportunity to learn te reo Māori, as well as study and experience important Māori customs and concepts.

This bicultural emphasis on the Ministry of Education’s policies today stems from the late 1980s, when biculturalism reflected in legislation such as the Education Act of 1989 (requiring individual schools to honour Te Tiriti principles) and the establishment of Kura Kaupapa Māori (Māori language immersion) schools were introduced to respond to Māori education inequity and low Māori school achievement rates (Lourie, 2016). Concurrently, the responsibility of deciding what and how to do this in practice was transferred from the central government to local school communities, with decisions being made by boards, school leadership, teachers and students (Lourie, 2016), many of whom through no direct fault of their own, were ignorant (Graham, 2003) because of a lack of training or professional development. The Tomorrow’s Schools educational reforms of the mid-1980s and subsequent education initiatives such as Education for the 21st century were supposed to be enabling and empowering for minoritised groups such as Māori (Johnston, 1998). However, despite decades of government-supported bicultural education advocacy, and the fact that 80% of Aotearoa New Zealanders perform well on an international scale (Hattie, 2003), the “bottom 20 percent (the ‘tail’) are falling behind at a rate greater than any other country in the world” (Bevan-Brown et al., 2015, p. 31). Aotearoa New Zealand holds “one of the greatest rates of disparity between those who achieve and those who languish”

(Bevan-Brown et al., 2015, p. 31), of which Māori continue to be "disproportionately overrepresented" (Bevan-Brown et al., 2015, p. 31). Māori, Pasifika, special education and students of low socio-economic backgrounds have all been identified by the Education Review Office (ERO) as low-achieving 'priority learners' needing improvement (Education Review Office, 2012; Te Kete Ipurangi, 2016).

In 2008, the Ministry of Education implemented the forerunner to the 2013 Māori Education Strategy, *Ka Hikitia - Managing Success*, designed to enable "Māori to enjoy and achieve educational success as Māori" (Ministry of Education, 2008, p. 6). The current phase, Accelerating Success (2013-2017), builds on the previous gains (and struggles) of the initial phase, Managing Success (2008-2012) and is guided by five key principles:

- Te Tiriti o Waitangi bicultural integration;
- 'Māori potential approach' in which schools view Māori students as learners capable of success and excellence [this approach was established to confront educational cultural 'deficit theories' (Bishop, Richardson, Tiakiwai, & Berryman, 2003, p. 6) where Māori were identified as the locus for educational discrepancies due to deficiencies in inherent ability, culture and/or resources];
- *ako* or reciprocal teaching and learning between teachers and students;
- importance of Māori identity, language and culture and
- productive partnerships of mutual respect between schools and their communities in which whānau are viewed as connected to, rather than isolated from, decisions and discourse regarding their children's education (Ministry of Education, 2013).

The above principles expanded upon prior Ministry of Education educator support material from the *Ka Hikitia: Managing Success* phase one, which detailed the *Tātaiako – Cultural Competencies for Teachers of Māori Learners* (Ministry of Education, 2012), required of teachers to effectively facilitate Māori succeeding as Māori in their classrooms. The five Tātaiako are:

- whanaungatanga: high expectations for Māori founded in strong relationships with students and whānau;
- wānanga: excellent communication, innovative problem-solving and co-construction of knowledge and learning goals within and outside of the classroom;
- manaakitanga: equitable, integrous approach to Māori people and culture;
- tangata whenuatanga: place-based, socio-culturally aware teaching and learning and
- ako: reciprocity in teaching and learning within the school and community (Ministry of Education, 2011).

These cultural competencies underlie many of the current Māori focused, Ministry-supported professional development initiatives such as *Kia Eke Panuku: Building on Success* (2015c) that build on earlier initiatives such as *Te Kotahitanga* (Bishop et al., 2003). The cultural competencies, as do all bicultural considerations explained above, align well with current literature regarding cultural responsiveness in conducting research, educational or otherwise, involving Indigenous participants (Edwards & Edick, 2012; Gay, 2010; Macfarlane, 2015; Savage et al., 2011).

Cultural sensitivity within Māori social research. Te Aka Online Māori Dictionary (2016) defines the Māori verb rangahau as to "seek, search out, pursue, research, investigate." Within Aotearoa New Zealand, the partnership, participation and protection principles of Te Tiriti o Waitangi apply when conducting rangahau that affects, involves or is relevant to Māori participants. Because of the deeply-embedded history of imperialism and corresponding dehumanisation, abuse, neglect and disregard of Indigenous voice in social research internationally as well as in Aotearoa New Zealand (Cram, 2001; L. T. Smith, 1999, 2005), and in recognition of the Māori position as the non-dominant Indigenous culture in Aotearoa New Zealand today, this literature review emphasises Te Tiriti principles as imperative in regards to Māori relationships. Notions of biculturalism in Aotearoa New Zealand necessitate specific protection for Māori (R. Walker, 2004) as research may affect the interests of Māori and non-Māori differently.

In the research context, the Te Tiriti principle of partnership requires researchers to work with iwi, hapū (subtribes), whānau and Māori communities to respect and guard both individual and collective rights (Massey University, 2015). The participation principle necessitates that researchers involve Māori throughout the entire research process (design, implementation and analysis). The protection principle requires researchers to "actively protect Māori individual and collective rights, Māori data, Māori culture, cultural concepts, values, norms, practices and language in the research process" (Massey University, 2015, p. 5).

The shift of power and control from dominant culture (Bishop, 2005; Cram, 2001; L. T. Smith, 1999) and the "colonizing gaze" (Hooks, 1992, p. 2) to Māori cultural interpretation and practices aligns with the values of kaupapa Māori research (Cram, 2016; Mahuika, 2008; S. Walker, Eketone, & Gibbs, 2006). Kaupapa Māori, research by Māori, about Māori, for Māori, is grounded in the principle of "tino rangatiratanga, which translates to sovereignty, self-determination, governance, autonomy, and independence" (S. Walker et al., 2006, p. 333).

Authentic kaupapa Māori research should incorporate Māori:

- historical experiences with, and perceptions about research;
- perspectives about the world;
- values and expectations around ethics;
- cultural values and practices and
- knowledge (Rautaki ltd, 2017, para 7).

The growth of theoretical positions on Māori [educational] research based on the implementation of Te Tiriti o Waitangi and its principles has significantly contributed to the Māori cause and, while these developments are on-going, they not only benefit Māori aspirations but also the 'greater good'; that is, the provision of education to all in Aotearoa New Zealand. The final section of this chapter explains the implications of my literature review for the direction and research design I selected for my culturally responsive mixed methods action research study into science differentiated and teaching and learning within a rural school setting in Aotearoa New Zealand.

Implications of Literature Review for my Mixed Methods Action Research Study

The preceding review of literature makes it clear that while inclusive education is purported as the panacea for addressing growing diversity in the classroom, the reality is that many students, including students with learning difficulties, exceptional students and students of non-dominant, minoritised cultures are not achieving to their potential in science. This has escalating impacts on the students, their whānau and society at large. The prominent, persistent gap between high- and low-achievement of Aotearoa New Zealand secondary students' scores on international science proficiency tests, and the overrepresentation of Māori and Pasifika students among low-achievers, indicates that there is a need for change.

Differentiation has been purported to be an effective strategy for meeting individual students' learning needs, but little evidence-based research exists within science education for how to best do this effectively and efficiently, either in Aotearoa New Zealand or internationally. Professional learning and development that integrates teacher, student and whānau experience, expertise and voice may help Aotearoa New Zealand science teachers overcome the many barriers and challenges that exist in implementing culturally relevant, responsive, effective, differentiated teaching and learning that meets the needs of diverse early secondary science learners.

Research purpose. This mixed methods action research study addresses the aforementioned gaps in research by investigating existing years 9 and 10 science differentiated teaching and learning practices from the perspectives of an Aotearoa New Zealand secondary school's science teachers, students and whānau. Teachers then applied those perspectives to collaboratively plan, implement and evaluate a differentiated unit designed in response to stakeholder input. The purpose of my research was to develop an evidence-base of practice for effective teaching and learning strategies that meets the diverse needs of today's science students – including Māori – within mainstream secondary science classrooms.

Research questions. The following research questions provided direction and focus for the study:

- How is differentiation of the science curriculum evidenced and understood by teachers, students and whānau?
- How can teachers work together collaboratively with a researcher to incorporate stakeholder input from teachers, students and whānau when planning differentiation of the science curriculum?
- How can the principles and practices of differentiation for gifted and talented students be adapted to understand, inform and implement differentiation of the science curriculum for all learners?
- How do teachers implement a collaboratively-designed plan for differentiation of the science curriculum?
- How does differentiation of the science curriculum impact student learning?

The philosophical and theoretical underpinnings, as well as strategies and tools for answering these questions, are detailed in the ensuing chapter on research design.

Chapter 3:

Research Design

Whāia te mātauranga hei oranga mō koutou.

Nothing can be achieved without a plan, workforce and way of doing things.

This mixed methods action research (MMAR) study investigated differentiated science teaching and learning at a rural secondary Aotearoa New Zealand school with the purpose of more effectively meeting the needs of years 9 and 10 students. The literature reviewed in Chapter 2 revealed that although differentiated teaching and learning are promoted both within Aotearoa New Zealand and the international educational community as a way to meet the unique needs of 21st century learners, very little research and evidence exists to provide teachers with the framework to do this effectively in mainstream science classrooms.

In this chapter, I present my pragmatist theoretical approach to research and discuss inherent assumptions and potential implications for research that result from holding this perspective. I next discuss the overall research design, or methodology, including the management of legitimation, ethics and concerns such as Māori cultural considerations. Research method details will be described alongside findings for each research phase in Chapters 5-7. This thesis structure reflects the cyclical, evolutionary nature of mixed methods action research, allowing me to discuss the development and modification of my methodology based on findings of previous phases, as well as interpret phase findings sequentially. The rationale for research site selection, my role as researcher, and a description of the participating school, teachers, students and whānau will follow in Chapter 4.

Research Perspective

Educational researchers take pride in designing and carrying out practical projects to solve human daily problems. We value educational inquiry for its potential to enrich both intellectual and social imagination, enlarging our perception of what is possible (Lukenchuk & Kolich, 2013). The topics we choose to research and the methodology we select for investigating, interpreting and communicating phenomena are done through what Denzin and Lincoln (2011a) refer to as a lens of highly abstract principles that include epistemology, questions regarding relationships between inquiry and what is known or discovered and methodology, both how we view the world and attain more knowledge about it. This interpretive framework, or "basic set of beliefs that guides action" (Guba, 1990a, p. 17) is called a paradigm (Denzin & Lincoln, 2011a; Guba, 1990b; Lukenchuk & Kolich, 2013). A paradigm is a "starting point or given that determines what inquiry is and how it is to be practised . . . [that] cannot be proven or disproven in any foundational sense" (Guba, 1990a, p. 18).

As acknowledged by L. T. Smith (1999; 2005), the values that form our lenses of viewing the world are greatly influenced by culture, ethnicity and community. Issues of power within societies can lead to both intentional and unintentional stifling of paradigms upheld and embraced by minoritised cultures such as many of the world's Indigenous peoples (Bishop, 2005). Even "the term 'research' is inextricably linked to European imperialism and colonialism" (L. T. Smith, 1999, p. 1) and carries horrific connotations of deception, abuse, exploitation and deception for many Indigenous and other non-dominant cultures. To help prevent further injustices from occurring, L. T. Smith (2005) argues that all social science paradigms should be articulated in ethical research to avoid the ignorance and assumptions that have plagued the tradition of colonial-mentality based research. Because I am a non-Indigenous Aotearoa New Zealand researcher and the student population at the school where I conducted research is composed of 49% Māori, my values and world view were likely different from those of my Indigenous students and whānau. A full understanding of differentiated teaching and learning within the research community required that I incorporate the perspectives from multiple stakeholders. As such, I approached my research from a constructivist epistemology, a dialectical pragmatist theoretical perspective and a mixed methods action research methodological approach.

Constructivists such as myself purport that "truth or meaning comes into existence in and out of our engagement with the realities in our world" (Crotty, 1998, p. 8). Because constructivists contend meaning is created rather than discovered, we accept multiple constructs of meaning by different people even when regarding the same phenomenon. This view of knowledge recognises that people of different cultures, ethnicities, communities, genders, ages and socioeconomic backgrounds experience reality differently based on the perspectives and concepts formed through interacting with the structure of the world around them (Maxwell, 2012). Therefore, the inclusion of multiple stakeholders' perspectives (teachers, students and whānau) was essential to designing my investigation.

As previously mentioned, I approached this research from the theoretical perspective of pragmatism. Pragmatism as a philosophical movement is often crudely summarised as what works, emphasises solutions to problems (Creswell, 2007; D. L. Morgan, 2014b; Patton, 2015) and links well with educational researchers' desires to expand human possibility. At its heart is the "pragmatic theory of truth" (Patton, p. 153), which is credited to have originated from the turn of the 20th century work of Americans Peirce, James and Dewey, who asserted that an idea or proposition is true only if it works in practice (Patton, 2015; Seale, 2012). Pragmatists reject the dichotomy of either-or thinking (R. B. Johnson & Gray, 2010) and maintain that there is no dualism between reality and idealism (D. L. Morgan, 2014b).

Dewey reoriented philosophy by emphasising human experience over abstract thought. He believed that experiences create meaning by bringing together beliefs and actions (D. L. Morgan, 2014b). Dewey noted that all such meaning-created experiences, referred to as transactions (Biesta, 2010), implicate contextual interpretation (D. L. Morgan, 2014b). As such, and in fitting with constructivist epistemology, today's pragmatic research paradigm recognises the impact of historical, cultural, social, political and other contexts in determining an effective working truth for any unique community (Lukenchuk & Kolich, 2013; D. L. Morgan, 2014b). Like other pragmatist researchers, I share Dewey's view of the world, one in which the human world is complex, composed of multiple realities and differences that should be viewed as opportunities to learn from and create new syntheses rather than be seen as incompatibilities (R. B. Johnson & Gray, 2010). As such, pragmatism is often referred to as a middle position paradigm for conducting mixed or multi-method studies. It allows for the collection and interpretation of multiple stakeholder perspectives of reality, transcending the traditional dichotomy between quantitative and qualitative research, (Cameron, 2009; R. B. Johnson, 2009).

Biesta (2010) and D. L. Morgan (2014b) question the validity of using pragmatism as a research paradigm despite its documented resurgence in 21st century social research (Greene & Hall, 2010; Ivankova, 2015; Tashakkori & Teddlie, 2003; Treagust, Won, & Duit, 2014). Morgan (2014) argues that pragmatism can, and indeed should, serve as a paradigm for research but warns against a simplified "what works" (p. 1046) stance. He argues that pragmatist researchers should explore both the 'how' and the 'why' of what they do in all phases of research, from selecting research questions to interpreting data. He declares that Dewey's essential components of contextual experience and inquiry as a process of self-conscious, cautious and reflective decision-making must be incorporated into all methodology and design if a study is to be considered genuine pragmatic research.

Like Dewey, Morgan (2014) argues that there is no divide between research and real life. Rather, research is a form of inquiry performed with greater care and consciousness than required by simple "problematic situations" (p. 1047) such as what to eat for breakfast or which radio station to listen to. Morgan identifies five key components of research that must be present if Dewey's concept of research as inquiry is to be realised in pragmatic methodology.

Pragmatic researchers must:

1. Identify a problematic situation;
2. Carefully define the problem in regards to research, reflecting on how the definition will impact the research;
3. Develop an action plan;
4. Evaluate the potential action plan (consider multiple consequences) and modify as appropriate and
5. Act!

These pragmatic components of reflection, problem identification, action plan development, implementation and evaluation align well with the principles of mixed methods action research, the research methodology I have selected for this research. Mixed methods action research enables experienced practitioners, such as teachers or medical professionals, rather than outside researchers, to design and carry out inquiries into problematic situations of everyday practice (Morgan, 2014).

Johnson and Gray (2010) agree that pragmatism as a research paradigm is sophisticated and complex rather than a simple approach to problem-solving. Teddlie and Johnson (2009) coined the term “dialectical pragmatism” (p. 88) to represent the dynamism a truly pragmatic paradigm holds for mixed methods research, providing the basis for multiple philosophical standpoints to interact with each other. In freeing the pragmatic researcher to creatively blend or construct research methodologies and designs, the scope of “workable solutions” (Johnson & Gray, 2010, p. 89) to address research problems is greatly expanded. Adhering to pragmatism’s principle of multiple realities, Johnson’s dialectical framework emphasises the need for researchers to respect, listen to and incorporate others’ viewpoints, and in so doing, remain open to “modifying their webs-of-belief in the pursuit of usable knowledge and social justice” (p. 89) as an investigation unfolds.

In summary, pragmatism, when dialectically applied in careful adherence to Dewey’s concepts of inquiry and experience, presents a highly relevant paradigm for social research today. Specifically, I selected pragmatism because of the freedom it enabled me to modify existing methodological approaches and design components to best address my diverse research questions. Furthermore, the ontological pluralism of pragmatism, which supports multiple complex realities, provided the theoretical foundation for the development of a variety of contextual instruments (online surveys, interview guides and classroom observation templates) to incorporate multiple perspectives of key stakeholders into my study conducted from within my rural school community including science teachers, students and whānau.

Mixed Methods Action Research Design

I selected a MMAR design because it suited my research aim of investigating differentiated science teaching and learning for years 9 and 10 science students through the incorporation of multiple stakeholders' (teachers, students, whānau) perspectives. Because MMAR is a relatively new field, I have chosen to explain the more familiar methodologies of mixed methods (MM) research and action research (AR) first and then describe what distinguishes MMAR from either of these approaches on their own. In doing so, I will explain the advantages and challenges to MMAR in approaching my research.

Mixed methods. Tashakkori and Creswell (2007) define mixed methodology "as research in which the investigator collects and analyses data, integrates the findings, and draws inferences using both qualitative and quantitative approaches or methods in a single study or program of inquiry" (p. 4). Its growing application in much of today's educational research (Hesse-Biber & Johnson, 2015; Ivankova, 2015; Jing & Huang, 2015; R. B. Johnson & Christensen, 2014; Plano Clark & Ivankova, 2016) and, indeed, across the behavioural, social and health sciences, in general, is due to its ability to comprehensively explore complex, real-world problems (Ivankova, 2015; Ivankova & Kawamura, 2010; Tashakkori & Creswell, 2008). Mixed methodology is pragmatic, empowering researchers to use a combination of the most relevant methods for fully answering social questions, rather than be restricted by the traditional dichotomy of qualitative and quantitative work (Ivankova, 2015). Many social science researchers view the fundamental characteristic of mixed methods research is the ability of the weaknesses of each individual method to be overcome when the strengths of both are combined in one study, or across a set of studies (Gelo, Braakman, & Benetka, 2008; R. B. Johnson & Turner, 2003; Wisniewska, 2011).

The complementarity nature (Greene, Caracelli, & Graham, 1989; Wisniewska, 2011) of mixed methodology enables practitioner-researchers such as myself "to address a range of knowledge generation and knowledge verification questions within a single study" (Ivankova, 2015, p. 3) in professional settings. More specifically, a mixed approach combines the strengths unique to (a) quantitative data – scores on instruments that generate specific numbers for statistical analysis to assess frequency and trends and that are capable of assessing large groups of people and (b) qualitative data – individual responses with actual words of study participants that offer a way to represent many perspectives regarding a research topic and allow for a more complex interpretation of the situation (Creswell, 2015a; Miles, Huberman, & Sadana, 2014). Greene et al. (1989) liken mixed methodology's ability to investigate multiple facets and alternative perspectives of a phenomenon to "peeling the layers of an onion" (p. 258). This onion-peeling characteristic gives mixed methods research the potential to hold more sway with policymakers than traditional dichotomised research, as it may be viewed as yielding "less waste of potentially useful information" (Gorard & Taylor, 2004, p. 7), incorporating an inclusive, fuller understanding of complex situations (Greene et al., 1989).

In order for such onion-peeling findings to be viewed as valid or reliable, however, several key issues or challenges to mixed methods data collection, design, implementation and analysis must be addressed (Ivankova, 2015). Preissle, Glover-Kudon, Rohan, Boehm, and DeGroff (2015) observe that the mixed methods "landscape is still developing and what is viewed as legitimate evidence remains politicized" (p. 144). Although "methodological purists have historically advocated incompatibility in combining quantitative and qualitative methods and data and the epistemologies associated with them" (Preissle et al., 2015, p. 148), even mixed methods advocates recognise challenges to ensuring overall quality within individual MM studies (Creswell, 2015a; Creswell & Plano Clark, 2011; Hesse-Biber & Johnson, 2015; Ivankova, 2015; Plano Clark & Ivankova, 2016; Tashakkori & Teddlie, 2010).

"Mixed methods studies in particular provoke varied opinions about rigor and the ability to make strong inferences with valid and reliable data" (Preissle et al., 2015, p. 148). The quality or legitimacy of inferences derived from mixed methods study is dependent upon the "methodological rigor" (Ivankova, 2015, p. 284) of data collection and interpretation both within and between the individual quantitative and qualitative strands (Creswell & Plano Clark, 2011; Ivankova, 2015; Maxwell, Chmiel, & Rogers, 2015; Onwuegbuzie & Johnson, 2006).

A key determinant of quantitative rigour is the accuracy with which quantitative data collection tools and strategies reflect consistent and accurate results, or the truth-value factor (Ivankova, 2015). Accuracy of reported findings from multiple perspectives (research, participants, reader) is a key factor in judging MM qualitative rigour (Creswell, 2014; Ivankova, 2015). Creswell argues that all high quality educational MM is transparent, identifying, describing and visualising the research design in a way that allows readers to both understand and critique the data collection and analysis strategies employed (Creswell, 2015a). As such, I provide a detailed description of the data collection and interpretation strategies I used both within and between (integration) the individual quantitative and qualitative strands in my methodology sections of Chapter 5-8.

The ability to investigate multiple layers of phenomena (both the overall picture and specific details), incorporate multiple perspectives (teachers, students, whānau) and have sway with policy makers (school leaders) is precisely what attracted me to mixed methodology for establishing my research investigation into differentiated science teaching and learning. However, I found mixed methodology, unlike action research methodology, did not in itself contain the community and practitioner emphasis I sought to achieve my aim of better meeting the needs of science students in the 'real' school environment where I teach and have long-established relationships with teachers, students and whānau. As such, the next section of this chapter will define and describe the scope of action research as it relates to my research intentions.

Action research. Action research is defined by Hinchey (2008) as "the process of systematic inquiry, usually cyclical, conducted by those inside a community rather than outside experts; its goal is to identify action that will generate improvement the researchers believe important" (p. 7). Its growing application in the social sciences and beyond is attributed to:

- a focus on practical, effective solutions to immediate, every-day problems;
- its aim to develop individuals and/or improve practice within communities and
- empowerment and/or emancipation rooted in social change (Altrichter, Kemmis, McTaggart, & Zuber-Skerritt, 2002; L. D. Brown & Tandon, 1983; Herr & Anderson, 2005; Ivankova, 2015; Kemmis & McTaggart, 2008; Schmuck, 2006; Stringer, 2014).

Lewin (1946), a German psychologist and contributor to change theory, introduced the term "action research" (p. 144), purporting that inquiry through action research empowered ordinary citizens to not only understand but change societal problems. His conception of action research as a cyclical spiral of reflection, planning, action and observation underlies the expanse of action research models that exist today (Calhoun, 1994; Hendricks, 2013; Henning, 2009; Kemmis & Wilkinson, 1998; Piggot-Irvine, 2006; Riel, 2013; Stringer, 2014).

Action research helps bridge the gap that often occurs between practice, research and theory (Elliott, 1991; Ivankova, 2016). Its participatory and collaborative nature engages multiple stakeholders throughout the investigative cycle and raises the potential of real and sustainable change within organisations (Ivankova, 2016; Meyer, 2000; Moyer, Coristine, Jamault, Roberge, & O'Hagan, 1999). Reason and Bradbury (2008) note that action research is a dynamic rather than static, predetermined process that evolves as those engaged in the investigation "deepen their understanding of the issues to be addressed and develop their capacity as co-inquirers both individually and collectively" (p. 4). Mertler (2014) and Schmuck (1997) assert that action research is an excellent methodology for studying and improving the actions and results of both teachers and students in authentic school settings, making it relevant to my investigation into differentiated science teaching and learning. Another of action research's advantages is that it is relevant to the context at hand and immediately applicable, providing teachers with the type of professional development promoted by Guskey and Yoon (2008), "just-in-time, job-embedded assistance as they struggle to adapt new curricula and new instructional practices to their unique classroom contexts" (p. 497).

Despite the many pragmatic advantages of educational action research, critics and action research advocates alike identify several challenges to quality issues in action research that must be effectively addressed to ensure quality action research design (Herr & Anderson, 2005; Ivankova, 2015; Koshy, Koshy, & Waterman, 2010; McNiff & Whitehead, 2011; Mertler, 2014). Ivankova (2015) observes, "In action research, practitioner-researchers should be concerned not only if the knowledge produced in the study is scientifically valid and credible but also if the study's practical outcomes stimulate change and empowerment of all stakeholders" (p. 259). Indeed, Kemmis and Wilkinson's (1998) caution that the criterion for measuring the success of action research should not be the execution of an excellent cycle but whether there is a genuine sense of understanding, development and evolution of practice among participants.

Therefore, the integrity of an action research project is based on both the quality of data collected and "the quality of action which emerges from it" (Jacobson, 1998, p. 130). Ivankova (2015) asserts that researchers must carefully consider and address the following quality considerations in practitioner-based action research design: balancing insider-outsider status, "achieving objectivity when studying their own practice, and deciding on the extent of the generalizability of the study outcomes" (p. 270).

Ivankova (2015) and Herr and Anderson (2005) suggest the following criteria for quality action research design of rigour:

- outcome validity – achievement of action-oriented outcomes;
- process validity – cyclical research design that presents and solves problems through a competent, reflective manner, promoting on-going individual or system-wide learning;
- democratic validity – inclusion of multiple perspectives of stakeholders in the collaboration process;
- catalytic validity – engagement of stakeholder leading to empowerment and change and
- dialogic validity – research design and findings subject to peer review.

Figure 3.1 visually represents Ivankova's (2015, 2016) application of Lewin's conceptual stages (introduced earlier in this chapter) to methodological action research steps: *Identification, Reconnaissance, Planning, Action, Evaluation, Planning* and *Further Action.*

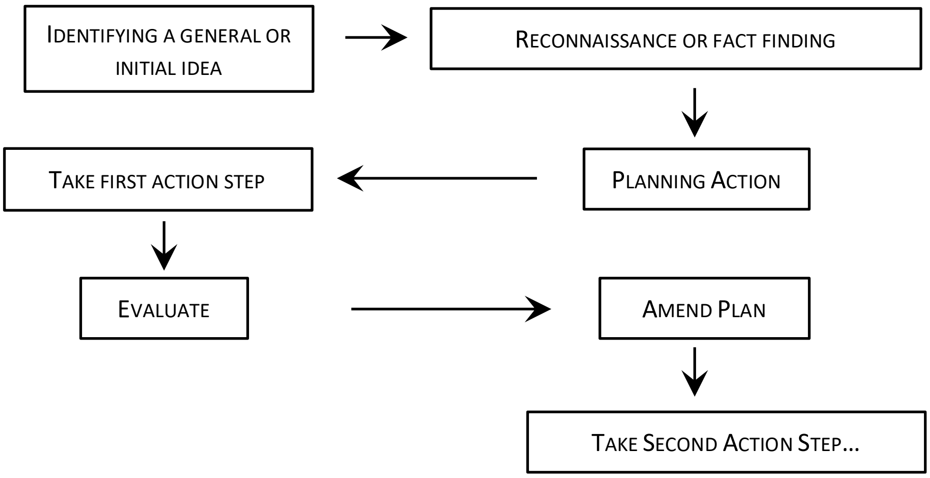

Figure 3.1: Ivankova's action research steps derived from Lewin's (1948) conceptual stages. Reprinted from Ivankova (2015, p. 38) with permission of SAGE Publications.

Ivankova's action research cycle informed my research design by providing me with a practitioner-based action research model that promoted authenticity and fluidity via multiple points of reflection and feed-forward from key stakeholders (democratic and dialogic validity) throughout the research process (process validity). The extent to which outcome and catalytic validity were met is described in methods and findings of Chapter 8, *Evaluating.*

The next section of this chapter provides the rationale for and challenges to integrating mixed methods with action research. A description of Ivankova's MMAR design framework and its application to my MMAR study design follows. Additional quality consideration challenges that arise from the integration of mixed methods with action research are discussed. More specific quality assurance procedures are also described in subsequent methodology chapters (Chapters 5-8).

Combining mixed methods and action research. Mixed methods action research has been increasingly promoted and utilised within the social sciences research community in recent years (Azmin, 2016; Basit, 2010; Gündogdu, 2015; Ivankova, 2015, 2016, 2017; Lyons & DeFranco, 2010; Martí, 2016; Rowell, Polush, Riel, & Bruewer, 2015). Advantages of a well-integrated MMAR approach include, but are not limited to, greater validity and credibility, better comprehensive situation or problem analyses, stronger action plans, more systematic monitoring and enhanced evaluation rigour, all of which promote sustainable change within the local community and greater transferability of research results to other settings and contexts (Ivankova, 2015).

Although mixed methods and action research are viewed by many methodologists as distinct research approaches (Creswell, 2015a; G. E. Mills, 2014; Wisniewska, 2011), they share several features that "make integration of mixed methods and action research justifiable and realistic for a variety of reasons" (Ivankova, 2015, p. 52). Ivankova (2015) identifies some of the common characteristics of mixed methods and action research to be a(n):

- shared goal of yielding comprehensive information through systematic inquiry,
- philosophical foundation of pragmatism,
- rejection of the quantitative/qualitative "incompatibility thesis" (p. 52),
- use of qualitative and quantitative data sources for collection and analysis,
- cyclical nature with distinct research stages,
- reflectivity of next steps arising from findings of preceding steps,
- collaborative nature utilised to discover "what works in practice" (p. 52) and
- incorporation of an insider-outsider perspective.

The shared characteristics between mixed methods and action research led Christ (2009) to call for action research to be accepted as a "form of mixed methods research" (p. 293) rather than its own methodology. However, current widespread "recognition of action research as a methodology rather than a single method" (Ivankova, 2015, p. 51) suggests that action research cannot be positioned within a mixed methods approach (Ivankova, 2015; McNiff & Whitehead, 2011). Indeed, Wiśniewska's (2011) research, for example, into the differences and similarities of mixed methods and action research in English language teaching, led her to conclude that each should be viewed as a "distinct research method" (p. 70). While both action research and mixed methods shared similar goals for "mixing methods and in data collection" (p. 70) they differed in use and combination of qualitative and quantitative strategies (p. 70), as well as in data analysis and presentation.

Ivankova (2015, 2017) recently developed a new methodological framework for MMAR to show how mixed methods can be effectively applied in quality action research. Illustrated in Figure 3.2, each step of her systematic model is a unique phase with clearly established boundaries. Adherence to systematic procedures for research conceptualisation, design and implementation is one way to increase the rigour, and therefore, the credibility, of my MMAR study (Edmonds & Kennedy, 2013; Ivankova, 2015, 2017). Ivankova's MMAR framework promotes distinct, defined phase starting and finishing points, with discoveries at each phase informing the direction and decisions made in subsequent phases. In her model, solid arrows represent the traditional action research progression; dashed arrows indicate other potential research iterations.

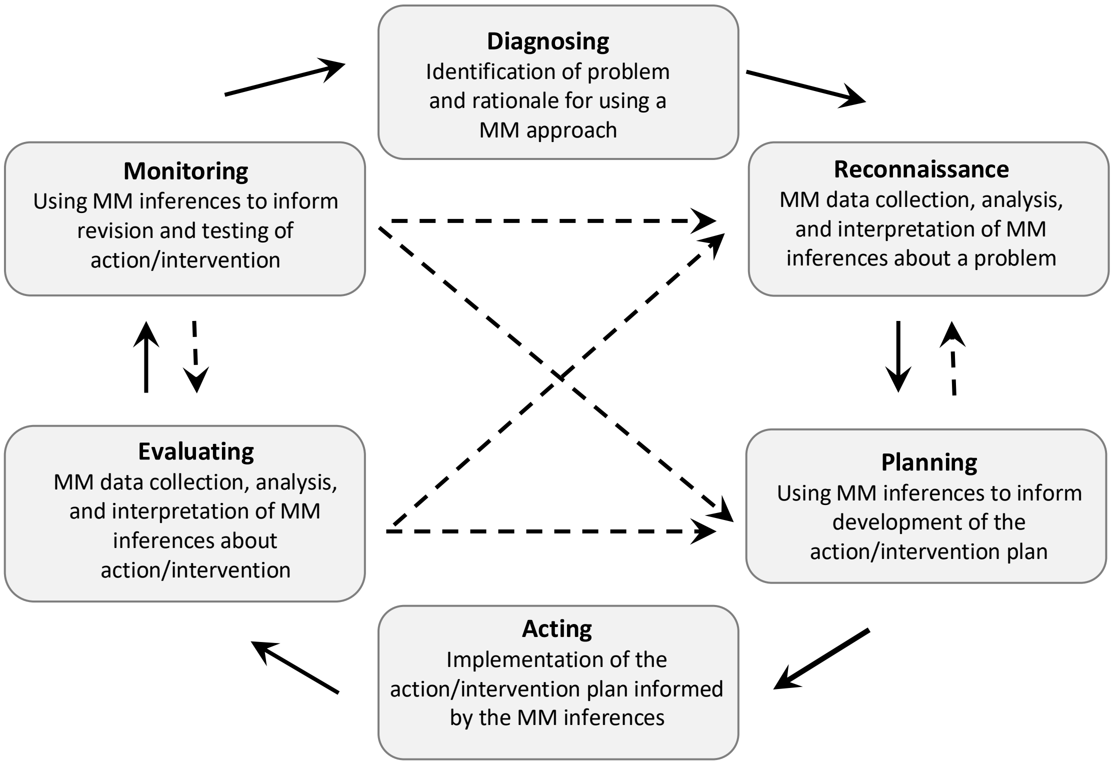

Figure 3.2: Ivankova's methodological framework for MMAR.
Reprinted from Ivankova (2015, p. 61) with permission of SAGE Publications.

As Figure 3.2 illustrates, the MMAR process begins in the *Diagnosing* stage, when practitioner-researchers identify and conceptualise a workplace problem or issue requiring a change or solution that can best be investigated and addressed through a combination of quantitative and qualitative methods. The study's overall plan including aim, objectives, outcomes and research questions is developed in this phase in response to consultation with stakeholders, the literature review and careful consideration of ethical issues. The next step is *Reconnaissance*, which occurs when practitioner-researchers select and embed a mixed methods design that systematically collects and analyses quantitative and quantitative data to assess the identified workplace problem/issue. This leads to the development of an evidence-based action or intervention plan in the *Planning* phase. Ivankova (2015) argues that the incorporation of mixed methodology in *Reconnaissance* "helps generate more thorough interpretations of the assessment results and create meta-inferences that inform the development of the plan of action/intervention" (p. 62).

In her *Planning* stage that follows, practitioner-researchers critically reflect on the *Reconnaissance* meta-inferences to create an action plan/intervention that addresses the problem. The *Acting* phase entails the implementation of the action plan/intervention and is followed by rigorous *Evaluating* through another embedded mixed methods study. According to

Ivankova (2015), *Monitoring* follows when practitioner-researchers reflect on the evaluative data and use those interpretations to "make decisions about whether the revision or further testing of the action/intervention plan is needed" (p. 62). Sample actions that practitioner-researchers could take at this stage include returning to diagnostics if the research problem or questions appear unfocused or unclear or if the implementation is judged as successful, continued evaluation of progress to promote sustainability and/or transferability of the MMAR study to other contexts and settings.

Figure 3.3 shows the research design I employed in my MMAR study into differentiated teaching and learning based on Ivankova's (2015) MMAR model and explain more in depth, in alignment with the MMAR cycle phases, in Chapters 5-7.

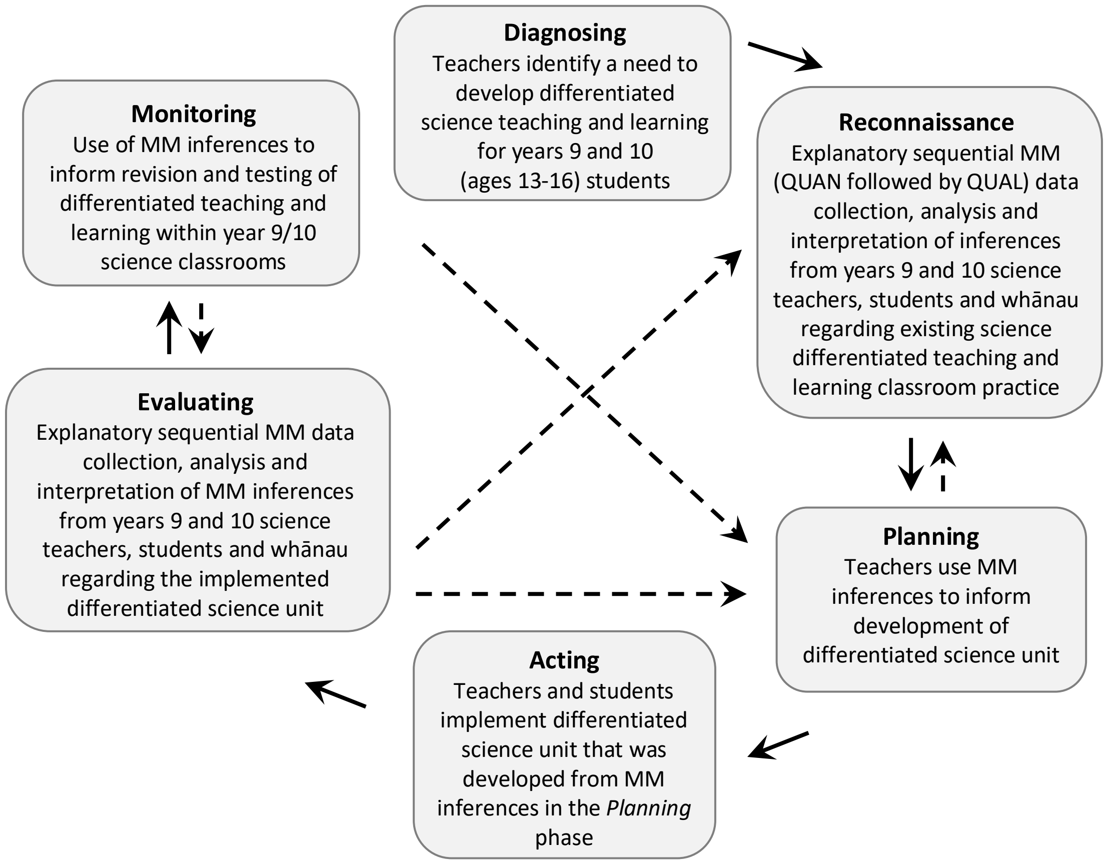

Figure 3.3: My MMAR differentiated teaching and learning research design. Adapted from Ivankova (2015, p. 73) and used with permission of SAGE Publications.

As Figure 3.3 shows, the mixed methods design that I selected to embed in the *Reconnaissance* and *Evaluating* phases of my research was the explanatory sequential design in which quantitative (QUAN) data collection and analysis is followed by qualitative (QUAL) data collection and analysis. The explanatory sequential MM design enabled me to use qualitative research to better explain and interpret my quantitative results (Creswell, 2015b; Creswell, Plano Clark, Gutmann, & Hanson, 2003), providing a more complete picture of science differentiated teaching and learning from the perspectives of teachers, students and whānau.

Given the multi-phase nature of my study and the large amount of collected data, I followed the recommendation (Creswell, 2015a; Miles et al., 2014) to interweave data collection and analysis throughout the research process. This enabled me to "cycle back and forth between thinking about the existing data and generating strategies for collecting new, often better, data … [making] analysis an on-going, lively enterprise that contributes to the energizing process of field work" (Miles et al., 2014, p. 71). I selected the interactive analysis model (Miles et al., 2014, p. 14) as the framework for research analysis. It identifies three simultaneous currents of analysis activity that should follow data collection: data condensation, data display, and conclusions. I found this model appropriate for my MMAR study because it allowed for innovation and flexibility to arise from reflection throughout the six phases of research.

Conducting research from a mixed methodology approach required me to skilfully combine quantitative and qualitative analyses. I conducted crossover analysis in both the *Reconnaissance* and *Evaluating* phases, which Onwuegbuzie and Combs (2010) state is mixed quantitative and qualitative analysis at its "most integrated form" (p. 426). This analysis involved using qualitative classroom observation and interview data to analyse quantitative survey data within the study. Such data analysis as a component of action research proved to be a dynamic process as I spiralled between reflection, collection and action (Creswell, 2015a).

In analysing my data I chose to focus on the results that most directly related to my research questions (Ivankova, 2015; D. L. Morgan, 2014a). Emphasis was also given to those results that:

- were highly positive or highly negative,
- displayed strong agreement or disagreement between stakeholders,
- showed strong agreement or disagreement between instruments and
- appeared most or least different pre/post *Acting* phase.

Patton (2015) states that an excellent researcher does his or her utmost, applying full intellect "to fairly represent the data and communicate what the data reveal given the purpose of the study" (p. 522). As I worked to transform data into findings (Patton, 2015), what and how I analysed evolved as the research unfolded. As previously explained, this evolution and its influence on how I drew and shared MMAR meta-inferences are further explained by research phase in Chapters 5-8.

Each phase of my MMAR approach was guided by specific research questions that influenced my research design and implementation. These questions, as well as the research phases and time frame under which they were explored, are illustrated in Figure 3.4. In adherence to Ivankova's MMAR model for research, my research did not proceed into subsequent phases until the relative data were collected, analysed and reflected on, including an acknowledgement of the results of the previous phase. For example, the teaching team did not begin the *Planning* phase until they had the opportunity to review *Reconnaissance* feedback from all stakeholders.

As previously discussed in this chapter, to best represent the responsiveness and sequential nature of action research, the specifics of the individual data-gathering MMAR methods employed in this study, the development and implementation of instruments, as well as data analysis procedures and their justification, are explained in detail with individual phase findings in Chapters 5-8.

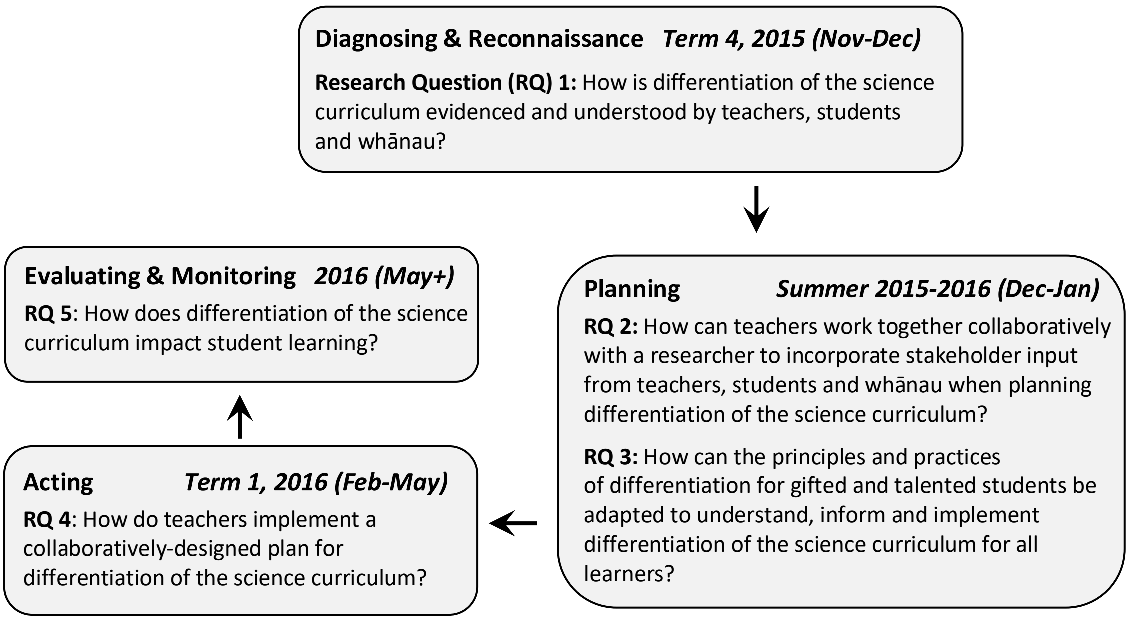

Figure 3.4: Differentiated teaching and learning research questions addressed by MMAR phase.

Because my research design included the engagement of multiple diverse stakeholders through its 6 phases (*Diagnosing* – *Monitoring*) in the school where I was employed as a science teacher, ethics concerns unique to educational MMAR needed to be addressed in addition to general social research ethics considerations. The next section of this chapter explains how ethical considerations impacted both the design and implementation of my MMAR study exploring differentiated science teaching and learning.

Ethics Considerations

To avoid exploitation of participants (Creswell, 2015a), particularly among marginalised people groups such as Indigenous, ethnic minorities, women and homosexuals (L. T. Smith, 2005), today's research ethics require all "research projects be subject to peer review and that human participation in research reflect the ethical principles of respect for persons, beneficence, and justice" (Preissle et al., 2015, p. 145). This section of the chapter begins by defining educational research ethics and then explores implications of these ethics for current social science research. I then proceed to explain how I addressed relevant ethical concerns in my MMAR design.

Definition and relevance of ethical social research. Ethics in educational research is defined by Simons (1995) as "rules of conduct that enable us to operate defensibly in the political contexts in which we have to conduct educational research" (p. 436). Regrettably, a review of history reveals that some research, even that which was deemed scientifically sound, subjected participants to unacceptable risk levels, "sometimes without the participants being aware that it ha[d] been so" (Royal College of Psychiatrists, 2001, p. 3).

Ivankova (2015) similarly identifies the following general ethical principles as critical to protecting the welfare of social research participants, including specific examples of the impact of each for research design:

- veracity – truthfulness; full disclosure to potential participants of all research objectives and protocol;
- trustworthiness and respect – assurance of participants' rights to autonomy and privacy through voluntary consent and secure anonymity and confidentiality;
- beneficence – obligation to not only prevent harm but perform "an advocacy role" (p. 110) so that both participants and the wider society benefit and
- justice – prioritisation of participants needs above research objectives; avoidance of discrimination by ethnicity, gender, demographics, etc.

To ensure ethical research within my PhD studies at Massey University, I considered the following principles as required by Massey's Code of Ethical Conduct (2015) for research involving human participants:

- respect for persons;
- minimisation of harm to participants, researchers, institutions and groups;
- informed and voluntary consent;
- respect for privacy and confidentiality;
- avoidance of unnecessary deception;
- avoidance of conflict of interest;

- social and cultural sensitivity to the age, gender, culture, religion, social class of the participants and
- justice (p. 4).

My research design involved carefully and clearly delineating all physical, mental, emotional, social and economic risks to potential participants through the process of informed consent. All research participation was voluntary, providing participants the option to withdraw or abstain at any point in the research process (2015). I submitted my ethics application for human research to the Massey University Human Ethics Committee (MUHEC) and received full ethics approval in September 2015 (see Appendix A). Ethical issues addressed in my MUHEC application and specific to my study are introduced in the following subsections of this chapter. Specific methodological actions taken in response to address these issues are further explained in depth in subsequent methodology Chapters 5-8.

Ethical considerations of educational MMAR. Within the general human research and educational ethical considerations introduced earlier in this chapter – veracity, trustworthiness and respect, beneficence, and justice – the participatory nature of educational MMAR research presented unique ethical challenges. Key ethical issues for my MMAR research design were: conflict of interest, power/authority, anonymity, confidentiality, informed consent of vulnerable (student) populations and cultural considerations as a culturally-engaged researcher. The following sections explain both the MMAR ethical concerns and how I managed them within my research design.

Potential conflict of interest. One of the most prominent risks, stemming from the action research component of educational MMAR design, was a potential conflict of interest between my practitioner-researcher professional responsibilities and research objectives/outcomes. Indeed, the pragmatic, contextualised, real-world approach of MMAR appeared to be in direct conflict with the Massey University Human Ethics Code which stated that "any project that puts [researchers] in a position where their activities as a researcher or teacher might come in conflict with their interests as a professional" (2015, p. 11).

Moreover, practitioner-led educational action research inevitably "brings into focus the issues of power and authority" (Ivankova, 2015, p. 113) in between a practitioner and his/her colleagues, students and students' whānau (Herr & Anderson, 2005). As such, precautions need be taken in educational MMAR to ensure that participants are not coerced, but instead, volunteer to partake in research of their own volition (Ivankova, 2015). The Massey University Human Ethics Committee (2015) cautions that in a research situation in which the recruited participants may "perceive themselves in a dependent relationship with the research" (p. 11) (e.g. students/teacher), the researcher must demonstrate that non-participation will not impact student performance or achievement.

To manage the potential conflict of interest, given my position as an educator at the school that was selected to form the core of the research community, I did not conduct any research while working full-time as a teacher within the science department. To address issues of power and authority in recruiting participants, the collection of informed consent forms for students – the 'dependent' population of my research – were facilitated through mediators (tutor teachers) as suggested by Ivankova (2015) and Tanke and Tanke (1982).

Although no research was conducted on students within my own classroom, it should be noted that 15% of the student participants had been previously taught science by me while I was a year 8 science instructor (in 2014). This potential conflict of interest actually served to strengthen the legitimacy of the research, as I had already established positive connections with teachers, students, and whānau, a key component for authentic participatory action research (Kemmis & Wilkinson, 1998; Mertler, 2014), especially among Indigenous peoples. L. T. Smith (2005), for instance, affirmed this notion when she stated, "the ability to enter pre-existing relationships; to build, maintain and nurture relationships and to strengthen connectivity are important research skills in the Indigenous arena" (p. 97).

Informed consent and respect for participant time commitment. Herr and Anderson (2005) define informed consent as "to the degree that they are capable, research subjects should be given the opportunity to choose whether or not to participate in the research; toward this end they must be given enough information to form this judgement" (p. 118). Ivankova (2015) identifies securing informed consent as one of the key ethical issues for all research, MMAR or otherwise, involving people. Informed consent is important for safeguarding participants' rights to make knowledgeable decisions about whether they want to participate or not and to what extent. Informed consent reduces the risks of intimidation or coercion. The cyclical, evolutionary nature of both the action research and mixed methods (Tashakkori & Teddlie, 2010) components of MMAR (Koshy et al., 2010) make it particularly challenging to predict the direction research will take as researchers alter their research course in response to emerging findings. As such, informed consent documents must be carefully thought through and additional ethics board approval may be needed as the study progresses in new directions (Ivankova, 2015).

Creswell (2015a) recommends that all mixed methods researchers in the field of education extend the informed consent process beyond study participants to include "gatekeepers" (p. 23) at multiple levels within the school (school board, principal, teachers, students, whānau) before conducting research to promote protection of human participant rights. Creswell's assertion of the ethical need to respect the school site where research is conducted through minimal disturbance to instructional time, staff workload and school budget is supported by the participatory nature of MMAR design in which research participants are active contributors throughout the research process from design to evaluation (Ivankova, 2015).

Approaching MMAR from a pragmatic theoretical perspective allowed me the flexibility to adjust both my research design and implementation in response to stakeholders' needs rather than adhere to a rigid, pre-determined inquiry model and, in so doing, facilitate representation more reflective of community diversity:

- allowing for modification of research instruments based on pilot study feedback,
- providing for the adjustment of qualitative focus group questions in response to emerging *Reconnaissance* themes and
- revising the research schedule to allow for participant work and holiday commitments.

To manage the ethical concern of informed consent in my MMAR education design, I included school "gatekeepers" (Creswell, 2015a) such as PhD supervisors, the school board, principal, science teachers, students and whānau throughout the 6 phases of research, including the diagnosing and design phase. Based on input from these gatekeepers, participants' information and consent documents (Appendices B-E) were revised, clarifying research objectives and intentions ahead of time before participants agreed to take part. My design allowed for research participants to be invited through a variety of ways such as assembly presentation, staff meeting and one-on-one invitations, in addition to written notification through the school newsletter and a research information sheet. No one was under any obligation to accept the invitation and participation was completely optional. Completion and return of the consent forms (Appendices C & E) indicated a willingness to participate.

In alliance with Te Tiriti o Waitangi's principles of partnership, participation, and protection, as translated in the MUHEC code, I designed my study so that research participants were aware that they had the right to:

- decline to answer any particular question,
- withdraw from the study at any time,
- ask any questions about the study at any time during participation,
- provide information on the understanding that their name would not be used unless they gave permission to the researcher,
- be given access to a summary of the project findings when it was concluded and
- ask for the recorder to be turned off at any time during a focus group discussion.

More specifics of the informed consent process, including seeking permission of "gatekeepers" at multiple levels of leadership in the school is further explained in Chapters 4 and 5.

Tikanga Māori (Māori values) were considered throughout my MMAR research design and are detailed in my discussion of cultural considerations as a culturally-engaged researcher later in this chapter. However, because two tikanga Māori are especially applicable to the concept of informed consent, they merit discussion here: titiro (looking and listening before speaking) and kia tūpato (being cautious).

In accordance with titiro, opportunities for any queries and responses were given before commencing any research activities including: online surveys, interviews, focus groups, collaborative planning sessions and classroom observations. As advocated by Ivankova (2015) for action research ethics, the teachers' consent for classroom observations included permission for me to view "routine activities… as part of regular practice" (p. 110) during classroom observations while acknowledging that my presence might affect student/staff behaviour. To promote kia tūpato, all research participants had my researcher contact details as well as those of my supervisors made available to them. I also created a research website, www.sweetassscience.weebly.com, to provide additional support and information.

The next section of this chapter explains the measures I took to safeguard anonymity and confidentiality of teachers, student and whānau participants in the research, both in and among study participants. Protection for anonymity and confidentiality when sharing research findings with and beyond my research community is also discussed.

Anonymity and confidentiality. The action research component of MMAR design presents unique ethical challenges regarding preserving participant anonymity during data collection, analysis and dissemination of results. Like many action research studies, my MMAR investigation was carried out in a small-scale work environment making it easy to recognise participants if I did not protect anonymity well (Ivankova, 2015).

An additional challenge to anonymity arose from the exploratory sequential nature of my mixed methods design requiring "permission to match data gathered at different times" (Bazely, 2010, p. 439). The credibility of a sequential mixed methods design depends, in part, on the same individuals participating in the quantitative and qualitative strands (Creswell & Plano Clark, 2011; Ivankova, 2015), "knowing who responded and how they responded to the survey questions is critical" (Ivankova, 2015, p. 113). Bazely (2010) therefore asserts that it is critical for mixed methods researchers to consider and address issues of anonymity and confidentiality such as linking data to participant response, using code names and seeking permission to follow-up in the informed consent process before data collection begins. Additional ethics issues unique to obtaining informed consent of participants within a MMAR design context are explained in the next section of this chapter.

In my MMAR study design, I made every attempt to maintain the anonymity of the data by keeping qualitative content confidential. Confidentiality agreements were created for qualitative interview participants, transcribers and me in my role as practitioner-researcher (Appendices F-H). Because I wanted to link initial qualitative responses to individual participants to assist me in following up in subsequent research phases (Ivankova, 2015, p. 110), I established pseudonyms for reporting any qualitative and quantitative data, the majority of which I planned to convey at an aggregated level. With supervisor input, I committed that any ethnicity linked to teacher attributes/training or participant qualitative responses would be reported as Māori or non-Māori rather than specific to ethnic groups such as Fijian or American to protect anonymity. All observational data were reported as mathematical totals and objective descriptions of the interactions. Given the small-school context of the research (Ivankova, 2015), I committed to ensuring the name of the college was kept confidential to keep teachers, students and whānau unidentifiable in any publications or presentations where findings were presented.

Information gathered was used only for the purpose for which it is collected. All reasonable precautions were taken to prevent unauthorised access, use, modification and disclosure of information gathered from participants. All non-identifying data such as data sets and transcripts used for the research were organised to be securely kept for five years to allow for academic examination, challenge or peer review. Any computer-generated writing/analyses were kept in a password-protected file within my computer. All thesis data used for published work were archived and all data analyses were conducted with pseudonyms or codes only; this research data were accessible only to myself as researcher, supervisors and Massey University recommended transcribers. All identifying data were kept secure in password-protected files and the consent forms were secured in my home office. All data were arranged to be kept for a period of five years upon which its storage and disposal are the responsibility of my supervisor.

Cultural considerations as a culturally-engaged researcher. Given the Māori context of the research community, the principles of Te Tiriti o Waitangi have featured significantly. Section two of the Massey University Code of Ethical Conduct for Research, Teaching and Evaluations Involving Human Participants (Massey University, 2015) specifies how Te Tiriti o Waitangi principles should be protected when research involves Māori participation or interests:

- The concept of partnership requires that researchers work together with iwi, hapū, whānau and Māori communities to ensure Māori individual and collective rights are respected and protected.

- The concept of participation requires that Māori are involved in the design, governance, management, implementation and analysis of research, especially research involving Māori.
- The concept of protection requires that researchers actively protect Māori individual and collective rights, Māori data, Māori culture, cultural concepts, values, norms, practices and language in the research process (p. 6).

A New Zealander of combined North American and European descent, I was culturally competent to carry out research with the Aotearoa New Zealand European demographic. However, I was also cognisant that even among my own demographic there are multiple worldviews and perspectives held (Cannella & Soto, 2010; Denzin & Lincoln, 2011b) that might influence how stakeholders view, interpret and experience differentiated teaching and learning (Kanevsky, 2013). Because I was familiar with, but not fluent in, te reo Māori and tikanga Māori, I worked under the mentorship of my thesis co-supervisor, Dr James Graham, who has an academic background in Māori education. A former teaching colleague of Pasifika decent and skilled in Pasifika cultural issues agreed to serve as a Pasifika cultural advisor when needed. I also engaged key whānau and teaching staff who were of Māori descent in on-going, professional relationships that provided me with their perspectives of the research process and community response to it.

In constructing my research design, I also considered each of L. T. Smith's (1999) seven kaupapa Māori practices (see first column of Table 3.1) derived from tikanga Māori to guide Māori researchers through a system of values that are placed on the way Māori behave. These kaupapa Māori practices form the foundation for L. T. Smith's (2005) culturally inclusive "community-up" (p. 98) approach (see Table 3.1) to defining researcher conduct (Cram, 2001; L. T. Smith, 1999), which also greatly influenced my creation of MMAR research design and implementation responsive to prospective participants of Māori whakapapa (ancestry/genealogy). The three columns of Table 3.1 provide an overview of L. T. Smith's Māori cultural values (1999), Cram's (2001) linked research guidelines, and their influence on my overall MMAR design; for example, allowing participants to set up time and location for research activities that worked best for them. More specific culturally responsive methodological applications such as the influence of L. T. Smith's (2005) 'community-up' principles on instrument and analysis design within the 6 phases of my MMAR are explained in corresponding subsequent methodological sections of Chapters 5-8.

Table 3.1: Applications of L. T. Smith's (2005) 'Community-Up' Approach to a Culturally Responsive Educational MMAR design

Cultural Values (L.T. Smith, 1999)	Researcher Guideline (Cram, 2001)	Influence on Differentiated Teaching and Learning MMAR Design
Aroha ki te tangata	Allow people to define their own space and meet on their own terms.	Allowed participants to set up time and location that worked best for them for all research activities.
He kanohi kitea	Meet face-to-face especially when introducing the idea of the research, "fronting up" to the community before sending out long, complicated letters.	Introduced research in-person on site to participants where I was available for questioning face-to-face within the community.
Titiro, whakarongo . . . kōrero	Look and listen (and then *maybe* speak). This value emphasises the importance of first looking and listening in order to develop understanding and find a place from which to speak.	Incorporated looking and listening into each of the six reflective MMAR phases. My MMAR reflective design facilitated engaging stakeholders collectively and individually through a mixture of qualitative and quantitative data collection and analysis tools and strategies.
Manaaki ki te tangata	Share, host, and be generous. This value underpins a collaborative approach to research, enabling knowledge to flow both ways, and acknowledges the researcher as a learner and not just a data gatherer or observer. It also facilitates the process of "giving back" of results and bringing closure if that is required for a project but not to a relationship.	Supported in the research design through the inclusion of quantitative and qualitative opportunities for stakeholders to provide input/direction throughout the MMAR process. Also evidenced in *koha* (compensation) of food and time.
Kia tūpato	Be cautious. This suggests that researchers must be politically astute, culturally safe and reflective about their insider/outsider status. It is also a caution to insiders and outsiders that in community research, things can come undone without the researcher being aware or being told directly.	Research design promoted indirect and direct communication with stakeholders allowing for adjustments in research strategies, tools and schedule, accordingly, in response to participant input.
Kaua e takahia te mana o te tangata	Do not trample on participant mana (dignity). This is about informing people and guarding against being paternalistic or impatient because people do not know what the researcher may know. It is also about simple things like the way Westerners use wit, sarcasm and irony as discursive strategies or even how/where one sits down.	Research design and implementation occurred under the guidance of PhD supervision and key school community stakeholders who were of Māori descent through on-going, professional and familiar relationships.
Kaua e māhaki	Do not flaunt knowledge. Find ways to share knowledge and be generous with knowledge without being arrogant. Sharing knowledge is about empowering a process, but the community has to empower itself.	Incorporated a variety of ways to share knowledge that facilitated collective growth as stakeholders explored science differentiated teaching and learning.

Legitimation

Because a MMAR investigation embeds action research in a mixed methods approach to research design and implementation, overall MMAR quality is determined by both the quality of the individual methodologies and the strength of the meta-inferences derived from methodological integration (Ivankova, 2015). Legitimation refers to the validation or assessment of such quality and is a critical component of the research process because it strengthens inference trustworthiness and the representative nature of the study (Ivankova, 2015; Onwuegbuzie & Johnson, 2006). Legitimation requires constant evaluation and responsive action throughout the study to ensure high-quality meta-inferences (Onwuegbuzie & Johnson, 2006). Maxwell (2013) asserts that when establishing quality research design, one should consider and address areas that most threaten research plausibility.

To help ensure that the inferences of my MMAR study are of high quality, my study addressed four types of legitimation introduced in Onwuegbuzie and Johnson's (2006) mixed methods legitimation model: inside-outside, sample integration, weakness minimisation and multiple validities legitimation (Ivankova, 2015; Onwuegbuzie & Johnson, 2006). An explanation of each type of legitimation and its implications for my exploratory sequential MMAR design ensues.

Inside-outside legitimation denotes "the degree to which the researcher accurately presents and utilizes the insider's view and the observer's view" (Onwuegbuzie & Johnson, 2006, p. 58). MMAR Legitimacy can be compromised when a research-practitioner neglects to collect and interpret data that fully represents participants' perspectives or gets too involved in the research (Onwuegbuzie & Johnson, 2006). To encourage insider perspective both quantitative and qualitative instruments were used confidentially with individual stakeholder groups. PhD supervision and stakeholder member checking throughout the research cycle promoted accurate interpretation through the process of peer review.

Sample integration legitimation refers to situations in which researchers intend to generalise from the participant group to a larger overall population (Onwuegbuzie & Johnson, 2006). To address this issue, my study design invited all teachers, students and whānau to participate in the *Reconnaissance* quantitative research but only invited those who partook in the quantitative surveys to partake in subsequent *Reconnaissance* qualitative interviews and follow-up *Evaluating* quantitative and qualitative data collection and analysis.

Weakness minimisation legitimation is defined as the "extent to which the weakness from one approach is compensated by the strengths from the other approach" (Onwuegbuzie & Johnson, 2006, p. 57). I addressed this in my research design by incorporating complementary quantitative and qualitative mixed methods data collection and analysis in the *Reconnaissance* and *Evaluating* phases. The quantitative methods were included to help me determine stakeholder beliefs and values regarding differentiated science teaching and learning whereas the qualitative methods were incorporated to help me better understand the reasoning behind participant thinking. The use of two methods enabled me to capture a richer explanation of what was currently happening in existing classrooms at the *Reconnaissance* and *Evaluating* phases, what stakeholders wanted to change and the rationale for their views.

Multiple validities legitimation refers to the "extent to which all relevant research strategies are utilised and the research can be considered high [quality] on multiple relevant 'validities'" (Onwuegbuzie & Johnson, 2006, p. 59). Relevant multiple validity legitimation issues to my research design introduced in this chapter, and further detailed in subsequent methods and findings chapters, include: outcome, process, democratic, catalytic and dialogic validity; potential conflict of interest; informed consent; anonymity and confidentiality, respect for school environment and culturally responsivity.

To encourage legitimation in the quantitative and qualitative strands of my research design, all instruments were peer-reviewed for clarity, accuracy and cultural responsivity by my PhD supervisors, teachers and/or students. Disclosure of my researcher beliefs and biases, introduced in Chapter 2 and described more in depth in Chapter 4, added transparency to research findings. While many potential meta-inferences could be drawn from integration of quantitative and qualitative findings, I chose to focus on those most directly connected to my research questions.

Summary

In this chapter I have introduced and explained the pragmatic theoretical perspective from which I approached this study. I then explained the characteristics of mixed methods and action research methodologies, justifying the embedding of mixed methods into action research as its own research methodology of mixed methods action research (MMAR). I presented Ivankova's (2015) MMAR cycle and its applicability to answering my research questions exploring science differentiated teaching and learning. In-depth discussion of the specific MMAR research methods employed in my study (tools and detailed analysis strategy), as well as a justification of their use, are shared in subsequent chapters, enabling me to present the in-depth analysis alongside research findings in a manner that supports the evolving nature of knowledge within a MMAR cycle. I introduced the rationale for ethics in social research, identifying first, the general ethical concerns – veracity, trustworthiness, respect, beneficence and justice. A description of ethical issues specific to my educational MMAR design followed: conflict of interest, power/authority concerns, anonymity, confidentiality, informed consent, respect for school environment including teacher/student learning time and Māori ethical considerations as a culturally-engaged researcher. The application of Te Tiriti o Waitangi and L. T. Smith's (2005) 'community-up' approach to conducting research to my research design were also discussed and contextualised with MMAR. A description of the threats to legitimation and how they were addressed in my research design followed.

My MMAR study design enabled me to investigate ways to more effectively meet the needs of years 9 and 10 science students at a rural secondary Aotearoa New Zealand school to achieve the study purpose of developing the evidence base of best practice models for differentiated science teaching and learning. In doing so, I also sought to:

- broaden educators' understandings of the development, implementation and evaluation of collaborative differentiated education strategies that integrate key stakeholders' perspectives (teachers, students and whānau);
- facilitate inclusive, educational environments that nurture all young people to develop their passions and potential as adaptive, responsive and engaged citizens who do not just consume but create new knowledge in the sciences and beyond and
- test the suitability of MMAR as an approach to educational research.

Although there were many unknowns, the potential to explore and implement practical strategies to enhance teaching and learning within the science department and school community that I work and love is what inspired me to undertake this MMAR study in the first place. The reasons for selecting my research site as well as an in-depth description of the research setting and my role as practitioner-researcher within the setting is further explained in Chapter 4. It serves as a prelude to Chapters 5-8 which detail the instruments used and resulting findings for the MMAR phases of *Diagnosing, Reconnaissance, Planning, Acting, Evaluating* and *Monitoring*.

Chapter 4:

Research Community

He aha te mea nui o te ao? He tangata, he tangata, he tangata.

What is the greatest thing in the world? It is the people, it is the people, it is the people.

MMAR design and implementation, as with any scientific inquiry, follows characteristic research protocol: topic identification, study aim and research question(s) formulation, sample selection, data collection and analysis, and findings interpretation/evaluation. Whereas Chapters 2 and 3 described the rationale for the research and introduced my MMAR study's research questions and design, this chapter details the context within which my MMAR design and methods were carried out. This attention to research setting is necessary to address MMAR quality and ethics concerns such as generalisability, process validity, conflict of interest and inside-outside legitimation discussed in Chapter 3.

I begin with an introduction to the secondary school and surrounding community, demographics, school structure and philosophical stance. I then explain my purposive and pragmatic rationale for selecting both the school and the years 9 and 10 science teachers, students and whānau as invited research participants. Next, I introduce my role as a practitioner-researcher, extending the explanations of the ethical considerations surrounding this role previously introduced in Chapter 3. Finally, I introduce the study participants – the teachers, students and whānau who expressed interest, provided consent and participated in the study – and describe how they formed a representative sample of the diverse, bicultural, rural school community in demographics, gender, year group and experience. Contextualising the research community will then lead into Chapter 5, where I provide a detailed description of the methods and tools implemented in the *Diagnosing* and *Reconnaissance* MMAR phases.

Research Site Selection

This MMAR investigation into differentiated teaching and learning took place within a rural, agrarian community in the Central North Island of Aotearoa New Zealand. Dairy farming was the dominant employment for members of the bicultural community; however, remnants of the previously stronger timber and dry stock (sheep, beef) industries also persisted. The community's decile 6[4], years 7-13 (ages 11-18), secondary school serviced a geographic area of 63 square kilometres and drew its student intake from 6 surrounding, rural primary schools.

Student enrolment at the commencement of research was 344 students with 49% identifying as Māori and 51% as Non-Māori. The school's leadership team and teaching staff had recently (2014) committed itself to enhancing the school's ability to better realise the Māori Education Strategy *Ka Hikitia's* (Ministry of Education, 2013) goal of Māori achieving success as Māori through its involvement in the Ministry of Education's 2013-2016 *Kia Eke Panuku* (2015c) professional development initiative. Specific *Kia Eke Panuku* initiative areas identified for growth within the school, and, subsequently, the science department, included:

- "leadership;
- evidence-based inquiry;
- culturally responsive and relational pedagogy;
- educationally powerful connections with Māori;
- literacy, te reo Māori and numeracy across the curriculum" (Ministry of Education, 2015, para 13) and
- closing the achievement gap between Māori and non-Māori.

Because of the school's commitment to eliminating the existing achievement gap between Māori and non-Māori students, study findings and quotations from individual teachers, students and whānau reported in this thesis are typically qualified as Māori or non-Māori. Although this research examined differentiation for Māori learners, the teaching intervention was not culturally differentiated in terms of content, process or product, but rather analysed for the impact of community-led differentiation on study participants of both dominant and non-dominant cultural backgrounds.

During the *Diagnosing* and *Reconnaissance* phases (2015) all students were timetabled in a rotating ten-day timetable with five one-hour specialist subjects per day. The majority of junior students' mixed-ability year group classroom time (years 7-10) was allotted for core subjects identified as mathematics, English, science, social studies and physical education/health.

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[4] At the time of research, the decile rating system was used in Aotearoa New Zealand to measure the socio-economic position of a school's student community relative to other schools throughout the country. A scale of 1-10, decile 1 represented the 10% of schools with the highest portion of students from low socio-economic communities, whereas decile 10 represented the 10% of schools with the lowest percentage of these students. The decile system was used to provide financial assistance to schools working to overcome learner barriers experienced by students of lower socio-economic communities. Lower deciles equated more funding (Ministry of Education, 2017).

Additional mixed-ability year group classes provided students with the opportunity to develop technology, music, dance, art and language skills. Students were first allowed choice of class options in year 10.

The school engaged a part-time Special Education Needs Coordinator (SENCO) to target and provide strategies for students that struggled with learning difficulties and/or displayed low literacy and numeracy skills. The school also employed teacher aides that worked closely with the SENCO but were not utilised in any of the observed years 9 and 10 science classes during my MMAR study. Rather, teacher aides were reportedly used primarily at National Certificate of Education Achievement (NCEA)[5] levels (Year 11 and above) for reader-writer purposes or years 7 and 8 National Standards[6] literacy and numeracy-orientated courses such as maths and English. The Gifted and Talented Education (GATE) Coordinator was away on leave and no replacement was made for that role with management units or personnel in 2015. In 2016, the Science Head of Faculty agreed to develop professional learning for the school staff that would increase teachers' abilities to meet the needs of gifted students in mainstream classrooms; however, as my MMAR study came to a close, he reported no progress in this area, citing an inability to follow-through in this role due to pressing commitments in other leadership areas such as mentoring new teachers within the science department.

The school promoted science as a mandatory subject through year 11, when students began NCEA. In response to a lower school-wide enrolment of 227 students in 2016, senior leadership adjusted the junior science timetable during the *Planning-Monitoring* phases to a five-day rotation with four 60-minute classes per week within seven mixed grade level classes (7/8 and 9/10). Implications of the unexpected timetable and class structure change on my MMAR research is explained in more detail in the methods and findings sections in Chapters 5-8.

During the course of my MMAR study, junior science class size (years 7-10) ranged from as small as 13 to as large as 28. Two school laboratories provided 8 student workstations equipped with 8 gas taps and 4 sinks to enable practical work for a maximum of 24 students

[5] At the time of research, the National Certificate of Education Achievement (NCEA) was Aotearoa New Zealand's national qualification system for secondary school students in years 11-13 (ages 15-18+). Implemented in 2006, NCEA consisted of three levels (1-3) and was designed to provide students with the opportunity to gain learning credits via both traditional school curriculum areas and alternative programmes. NCEA qualifications were used as a benchmark to gain university entrance as well as post-secondary employment (New Zealand Qualifications Authority, 2017).

[6] National Standards were implemented in Aotearoa New Zealand in 2008 by the National Government as benchmarks for determining and monitoring student achievement in the primary sector. In December 2017, the newly elected Labour government abandoned them and is currently working with the Ministry of Education to replace them with an alternative system that "better acknowledges a child's progress and focuses more on developing key competencies for all learners" (Ministry of Education, 2017, para 1).

working in groups of 3 at any one time. An additional half-laboratory provided science classes with extra investigative space but was limited to 4 student gas taps and 3 sinks. Shared use of laboratories and non-science classrooms for teaching and learning required teachers to communicate within the department for timetabling of hands-on activities and use of department materials. The science technician employed by the school prior to 2016 was made redundant due to budget cuts; as such, teachers in the *Planning* and *Acting* phases were expected to coordinate, source and prepare any materials needed for hands-on investigations.

The selection of this school for research was both purposive (Cohen, Manion, & Morrison, 2011; Teddlie & Yu, 2007) and pragmatic. As a researcher, my six years of teaching years 7-12 (ages 11-17) science and a range of other subjects (English, Spanish, mathematics, music, social studies) within the school, as well as leadership roles such as research and development manager, assistant head of science, gifted and talented education coordinator, teacher in charge of year 8 education outside the classroom (EOTC) and Te Kura (correspondence) school facilitator, provided me with a sound foundation in the mechanics of the education system. These experiences gave me prior insight and access into school structure and policies ranging from changes in leadership and professional development initiatives to department curricula, evolving school goals and on-going successes and challenges when confronting student engagement and achievement. My invested commitment in the school community created a strong desire within me to make a positive difference in the lives of participating staff, students and whānau.

A purposive community approach. My position as teacher and community member prior to the commencement of the research also provided previously established professional and collegial relationships with school leadership, staff, students and whānau. These relationships aligned with L. T. Smith's (2005) 'community-up' approach (Table 3.1). As a school community member, I had the distinct advantage of conducting my MMAR investigation through Messiou and Ainscow's (2015) lens of a 'purposive community' (p. 247) or as Wenger (1999) originally identified it, 'a community of practice' (p. 6).

Messiou and Ainscow's (2015) purposive community approach identifies several advantages to sustainable change conducted from within, rather than from outside, the community including, but not limited to:

- more extensive, in-depth interactions among participants;
- bona fide accountability that continues over time;
- genuine evaluative measures and
- meaning derived from locally produced, rather than externally imported, artefacts and resources.

A purposive community approach promotes vulnerability, honesty and risk-taking among participants. My role as a science teacher within the school enabled me to conduct a purposive MMAR investigation into differentiated science teaching and learning to better meet students' needs from within the school setting that I work, grounded in existing collegial teacher, student and whānau relationships. Participating teachers in my research study agreed to not only open their 'real' classrooms and teaching practices for my practitioner-researcher classroom observations but were also open to reflecting on the science department's teaching and learning strengths and weaknesses from personal, collegial, student and extended community (whānau) perspectives. Part of their willingness to participate stemmed from the fact that confidentiality of names would be upheld. In addition, my teaching practice was also under scrutiny through students' recollections of science learning experiences with previous teachers at the college.

As a practitioner-researcher, I possessed first-hand experience with the struggle of how best to address diversity within the classroom; I knew that observed classroom reality is often not what was planned (for the better or for the worse). Experts argue that professional development that arises from within purposive, collaborative communities such as the school involved in my study encourages sustainable change over time (Messiou & Ainscow, 2015; Wenger, 1999). As a science department we set out to purposively explore and grow in our capacity to differentiate to meet all learners' need, but particularly those students at the ends of the learning spectrum with exceptional science talent and/or learning difficulties. Teachers hoped to stop the exodus of transferring gifted years 9 and 10 students and their whānau who reported talented students' needs were not being met by existing teaching and learning. Teachers also wanted to provide adequate scaffolding to accommodate students with learning difficulties to pursue science successfully at the NCEA levels.

Strike (2010) agrees that sustainable change stems from community driven reform. His community paradigm for school reform is characterised by high autonomy for teachers, intrinsic motivation for teachers and students alike, accountability within the profession among colleagues, authentic instruction and depth over mere coverage, individual success and ethical relationships. Selecting the small school where I teach aligned with his observations that small schools are ideal for co-creating knowledge. He argues that one of the key advantages to a small school is that it provides the opportunity for a "small, intimate learning community where students are well known and can be pushed and encouraged by adults who care for and know about them" (p. 2). Strike maintains that a "We're In This Together"(WITT) approach rather than a "You're on Your Own" (YOYO) tactic is essential for student improvement (p. 157). Students attending small schools are less at risk of the large school phenomenon of "beginning as and remaining a world of strangers" (p. 5).

Certainly, a review of 57 post-1990 empirical investigations into school size in the United States and the United Kingdom led Leithwood and Jantzi (2009) to conclude that academically and socially disadvantaged students receive the most benefit from attending small schools. As such, they propose limiting the size of secondary schools composed of students from diverse, non-dominant cultural backgrounds to 600 students or fewer. Indeed, reductions in secondary school size have also been shown to improve both student achievement and attainment among middle and high school students in the United States particularly within educationally and economically disadvantaged communities (H. S. Bloom & Unterman, 2014; Egalite & Kisida, 2016).

However, as educational researchers Leithwood and Jantzi (2009) acknowledge, issues regarding the cost-efficiency of schools remain a concern in today's economy. Kuziemko (2006) asserts too small of a school may not be cost effective but does not indicate what size that is. Other factors of consideration for school size include course specialisation and networking opportunities with a variety of peers and teachers (Kuziemko, 2006). Similarly, Luyten, Hendriks, and Scheerens (2014) caution against making broad assumptions about the direct impact of school size on student cognitive and non-cognitive growth, citing likely mediating factors in schools of any size including school climate, class size and institutional structure. Luyten et al. (2014) also observe that the degree that school size influences student achievement varies greatly between countries, communities and student demographic populations.

Findings within the limited research in Aotearoa New Zealand (Alexander & Jaforullah, 2005) on efficiency and secondary school size indicate that low socio-economic status and rural isolation can present barriers to school efficiency when it comes to learning for students. Strike's small school "We're In This Together" (WITT) approach has the potential to confront these challenges committing to both *Ka Hikitia's* goal of Māori achieving success as Māori and my school's charter promise to uphold Te Tiriti o Waitangi principles of partnership, participation and protection. WITT may also have the aptitude to respond to the call for culturally responsive educational environments for Māori children, inclusive of whānau (Bevan-Brown et al., 2015). Indeed, by the time pupils at my school reach NCEA Level 3, at the average age of 17, science teachers have interacted with students and whānau for 6 years, an equivalent amount of time to their entire primary school experience.

My research contributes to Aotearoa New Zealand and international literature because it used a new approach (MMAR) to conduct community driven research in education. It explored ways to utilise WITT relationships that exist in small schools to better differentiate to meet learner needs. Using a MMAR approach enabled me to engage the teachers, students and whānau in the small school in the rural bicultural community where I taught to implement and evaluate a differentiated science teaching and learning in response to community input, affording me the opportunity to potentially improve the lives of those I cared about and extend my professional learning.

My Role as Researcher

Prior to commencing my doctoral studies, my science department colleagues and I collectively selected the topic of differentiated teaching and learning in mid-2014 as an area for professional exploration and growth. I, with a passion for evidence-based practice, agreed to guide the journey. My successful receipt of a TeachNZ[7] teacher study award for full-time study-leave and a Massey University Vice Chancellor's Doctoral Scholarship enabled me to explore this topic as the lead MMAR investigator, conducting data analysis in a manner that was ethically secure, allowing students, whānau and teachers to share information confidentially.

However, my role as both teacher and researcher still presented unique tensions for conducting MMAR. Such challenges included:

- potential bias (both positive and negative) from previous interactions with and/or established relationships among teachers, students and whānau;
- situations in which teachers, students and/or whānau views contradicted each other and/or classroom observations;
- reports from students that teachers were altering (improving) teaching practice during classroom observation days;
- pressure from leadership and staff to share confidential teacher interview data and/or classroom observations;
- pressure from colleagues to emphasise particular themes in research findings and
- frequent references to my teaching practice by teachers, students and whānau as quality differentiated teaching and learning.

To help address the ethical concern of a potential conflict of interest (previously introduced in Chapter 3), I neither served in leadership roles nor taught any classes at the research site while conducting this investigation. I conducted the literature review, instrument development, ethics approval and MMAR data collection and analyses (surveys, focus groups, interviews, classroom and collaborative planning session observations) throughout the two-year

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[7] Ministry of Education funded study scholarship programme designed to support teacher and principal professional development (TeachNZ, 2018).

investigation. A detailed discussion and analyses of these research methods and tools follows in Chapters 5-8. With my support, participating teachers collaboratively planned (Summer 2016) and implemented (Term 1, 2016) a differentiated teaching and learning unit that responded to *Reconnaissance* findings.

Study leave allowed me the flexibility to coordinate interactions with stakeholders in accordance with L. T. Smith's (2005) 'community-up' research component of aroha ki te tangata, meeting on participant terms in times and spaces selected by them. Research activities were not restricted, as in much practitioner-based research, by my teaching workload, availability of shared non-contact periods or lunch/interval duties. Study leave allowed me to provide teachers, students and whānau with multiple engagement opportunities at a variety of times and locations. Although I had ethics approval to begin research in September, we did not start data collection until November due to teachers' requests to wait until senior exam study leave began. Aroha ki te tangata also required coordinating student focus groups around lunchtime sports practices and music rehearsals and arranging whānau focus groups in ways that provided for work and whānau commitments. Even fulfilling students' koha requests of delivering hot Domino's pizzas or homemade blueberry muffins directly from town were made more feasible by the flexibility allotted through study-leave.

Despite continual communication with all groups of stakeholders via in-person, school notices, social media, e-mail, text and phone conversations, unexpected changes still arose. Because I was no longer constrained by my own teaching timetable I could respond to these alterations with flexibility, encouraging *Reconnaissance* that was authentic, not prescribed by schedule.

As a pre-existing teaching member of the school community, with both on-site and remote access to school database and communication tools, I could limit the increase in workload that MMAR required of other teacher participants. On-going database access was agreed upon as part of the school's consent to participate. Access privileges enabled me to generate all digital and printed research notices for teachers, students and whānau; help coordinate and direct research-related information assemblies; reserve computer and/or meeting rooms and, access all previous and current student achievement files. In addition, access to the development of the school calendar meant I had a big picture approach to planning, avoiding areas of high stress such as assessment weeks for students or reporting deadlines for teachers. However, I was also careful to ensure that access privileges were not abused and I abided by the participant protection conditions established in the school consent process and described in this and previous chapters.

Finally, when initial numbers of returned consent forms of student participants were low (for example, particularly in the numbers of Māori, male, and scientifically talented year 10 participants) I used my pre-existing relationships within the community to engage with and re-invite underrepresented students in casual lunchtime conversations outside of class. Similarly, I directly contacted some of the underrepresented whānau caregivers. Such dialogue contributed to increased stakeholder interest in participation, enabling me to conduct purposeful sampling that was more representative of the school's diverse community, and is explained in detail in the next section of this chapter.

Research Participants

All prospective (2016) years 9 and 10 (aged 12-15) students (*n* = 88; year 9 = 57, year 10 = 31), their science teachers (*n* = 4) and whānau (*n* = 200+) were invited to participate in the research. The years 9 and 10 ethnic composition reflected the wider school demographics, with 55% identifying as Māori and 45% as Non-Māori; gender representation was similarly split with 55% male and 45% female. Of the 48 students recognised as Non-Māori, 46 identified themselves as New Zealand European and 2 as Pasifika.

This age group was identified as the target group because they had taken 2-3 years of science at the college, most with a variety of teachers, and thus, had an extensive experience from which to base their perspectives. In addition, the Ministry of Education had identified years 9 and 10 as an awkward gap, between the end of National Standards and the start of NCEA qualifications, that needed monitoring (Laxon, 2013). Furthermore, year 10 was the final year that general science was mandatory at the college as students had the opportunity to take agricultural science or general science in year 11 for level 1 NCEA.

Participating teachers. Over the course of the two-year research investigation, four years 9 and 10 science teachers (3 males and 1 female) agreed to and participated in the survey. No years 9 and 10 science teachers withheld from the study and only three teachers participated in the research at any one time. This was because one of the initial participating teachers was transferred from the science department to the mathematics department in the summer of 2016 and the school employed a new science teacher who also agreed to partake in the study. As detailed in the ethics section of Chapter 3, any teacher contributions to this research are referred to and displayed confidentially via pseudonyms (Alton, Sage, Casper, Turin) to protect identity. Table 4.1 presents a summary of participating teacher background by teacher, including educational qualification(s), teaching experience, science subject expertise and training specific to differentiated teaching and learning. A description of these areas of teaching background, as well as teacher participants' motivation for teaching, are then explained in greater depth in the following sub-sections of this chapter.

Table 4.1: Summary of Teacher Participant Background Characteristics

Teacher Pseudonym	Qualification(s)	Teaching Experience	Subject Expertise	Training in Differentiation
Alton	• Bachelor's Degree with honours in Environmental Science (overseas)	• 21 years of science teaching experience overseas and in Aotearoa New Zealand • 6 years of science teaching at current school	• Environmental Science	• In teacher training, lots of theory, occasional examples but not much practical. If anything, it was to differentiate tasks or by class. • None in past 5 years that was effective.
Sage	• Bachelor's Degree in Agriculture Science • Graduate Diploma of Teaching	• 7 years of science teaching at current school	• Agriculture Science • Biology	• Minimal, little bit in studies at university. • Teacher-training, 1 module. • Nothing in past 5 years.
Casper	• Bachelor's Degree in Science (overseas) • Master's Degree in Chemistry (overseas) • Post-Graduate Diploma of Teaching	• 34 years of science teaching overseas and in Aotearoa New Zealand • New to school in 2015	• Senior Mathematics, Physics and Calculus (year 11+) • "Have done Biology but don't like it!"	• At previous schools talked of differentiation for gifted students and grouping by ability. • No other relevant differentiated training in past five years, but would be good - better experience for all!
Turin	• Bachelor's Degree in Science • Post-Graduate Diploma of Teaching	• 16 years of science teaching in Aotearoa New Zealand • New to school in 2016	• Biology	• Strong science department at previous school where Head of Faculty was big into differentiated teaching and learning and department was well-supplied with lab technician, etc.

Teachers' background, training and experience. All participating teachers were trained in and degree-qualified for teaching secondary science, two in Aotearoa New Zealand, and two internationally. One teacher acknowledged Aotearoa New Zealand Māori ancestry; the other three teachers identified as non-Māori. All teachers cited specific science disciplinary areas of expertise that they were most passionate about, comfortable with and competent in teaching, either due to training qualifications, previous teaching or life experience. Examples included agricultural science, biology or physics (see Table 4.1) but these subjects were not necessarily what teachers were teaching during my MMAR study. Participating teachers' experience ranged from 7 to 34 years of science classroom teaching experience in Aotearoa New Zealand and overseas. Teachers' experiences at the school ranged from 1 term to 7 years.

Teachers' motivation for teaching. Participating teachers cited different motivations for teaching. However, all four teachers expressed an on-going desire to engage students in relevant, meaningful learning, and they maintained a hunger for learning and love for developing rangatahi. Casper was motivated to become a teacher through a family legacy of teaching, but was especially influenced by an uncle, the inspirational headmaster of 1,700 students. Alton, Sage and Turin stated family commitments as the primary reason for switching from other careers (i.e., farming or science research) to secondary education. Alton pursued a teaching degree as a gateway to outdoor education but found traditional school-based education more suitable to parenting a young family. All four of these teachers found teaching an excellent career as a parent, raising two or more children. Sage, however, acknowledged that teaching science was "harder than I thought", reflecting that the 21st century classroom is "different from how I remember it as a student. I thought students would sit down, be quiet, and want to learn" (individual interview). Sage also shared that the time commitment outside of the classroom needed for preparing for science was much more than originally anticipated (individual interview).

Teachers' classroom goals/philosophy. In individual interviews, all four participating teachers identified "student learning" either directly or indirectly as a critical indicator for achievement of their goals as a science educator. Their individual philosophy on how to best facilitate student learning differed in its emphasis but tended to focus on student engagement or relevance of content and process. Alton, an experienced teacher (n = 21 years) and science faculty leader, strived to, "get [students] all engaged and positive about what they are doing and learning in the sciences." Sage, the least experienced participating teacher (n = 7 years), stated a similar goal, "for students to learn something in a positive, enthusiastic way." Casper, on the other hand, emphasised the importance of authenticity and relevance, desiring "to make [students] feel a need for knowledge. To create situations where they need to know." Turin hoped "for every student to at least once in the year get that spark (aha!) moment," further clarifying, "every day would be great, but at least once a year."

Previous professional development in differentiated teaching and learning. Differentiation was not a new concept to any of the participating teachers. Yet, only Turin had any prior hands-on differentiated learning and teaching professional development which he believed to be relevant and practical for classroom practice. He cited the "strong science department at [a] previous school where Head of Faculty was big into differentiated teaching and learning" (individual interview) as an excellent working example of modifying curriculum to meet diverse students' learning needs.

The other teachers had been told differentiation was important and necessary by those in authority such as Ministry of Education officials, school leadership or previous tertiary instructors, but had not been given specific strategies, exemplars or tools for effective classroom differentiation implementation in the sciences or otherwise that they viewed as practical or applicable. Alton recalled during teacher training (several decades prior) that differentiation was addressed through "lots of theory, occasional examples but not much practical. If anything, it was to differentiate task or by class" (individual interview). Casper similarly reported that colleagues at previous schools approached differentiated teaching and learning by cross-grouping high-ability students, but he knew of no practical support for what to do in mainstream mixed-ability classrooms.

Participating students. Twenty-six year 9 (47%) and thirteen year 10 (41%) obtained permission from their caregivers and agreed to participate in the differentiated teaching and learning research. All students who expressed interest in participating and provided consent were allowed to partake in this MMAR investigation. Multiple opportunities and reminders for obtaining caregiver consent were provided from both myself as researcher and the students' science and tutor teachers. Students who expressed interest in participating but neglected to obtain caregiver consent did not contribute to the research.

Demographic information was obtained, as per ethics approval, via the school KAMAR[8] database. The KAMAR student details' database was derived from student enrolment forms (most of which had been completed by caregivers when enrolling their children in year 7). If the caregiver had listed New Zealander or unstated as the ethnic group, I contacted the students or whānau via social media, e-mail or phone to clarify ethnicity.

Table 4.2 contrasts the demographics for research participants against the composition of the attending years 9 and 10 student body cohort and the overall enrolled school population, revealing a somewhat representative nature of the student research sample. Seventeen year 9 girls, nine year 9 boys, eight year 10 girls, and five year 10 boys participated in the study. As such, female students' perspectives were more likely to be overrepresented in *Reconnaissance* data collection and analysis while males' perspectives were more likely to be underrepresented. Similarly, the representation of Māori among study participants at 38% was slightly lower the

[8] School management system (SMS) designed for Aotearoa New Zealand school administration and utilised by the participating school "to collect, store and access student information and also provide information to parents and the school community . . . including online awards, home contact, pastoral, resource booking, reporting and timetabling" (Clarke, 2015, paras 1 & 5).

percentage of Māori among the years 9/10 cohort (45%) and school population (48%). The 62% of non-Māori participants identified themselves as Aotearoa New Zealand European (*n* = 22; 56%) or Pasifika (*n* = 2; 6%), resulting in a dominantly bicultural research student population.

Table 4.2: Demographic Comparison of Research Participants to Years 9/10 Student Cohort and Overall School Population

Culture and Gender	Research Participants *n* = 39	Years 9/10 Cohort *n* = 88	School Population *n* = 344
Māori	38%	45%	49%
Non-Māori	62%	55%	51%
Male	36%	55%	50%
Female	64%	45%	50%

All but one participating year 9 student had attended the school for at least 2 consecutive years; all but two year 10 students had attended the college for 3 consecutive years. A Pasifika student was the only new international immigrant (2014) to the school. The majority of the 39 MMAR student participants (67%; *n* = 26) held previously established relationships with me as their classroom science, Spanish or form teacher; an additional 31% (*n* = 12) knew me through extracurricular activities such as athletics, cross-country and swimming sports, education outside the classroom (EOTC) camps or year 7 inter-form competitions. The only student participant I did not know was new to the school in 2015.

Participating whānau. All whānau of years 9 and 10 students at the college were invited to be part of a focus group. The 7 whānau who expressed interest and participated in the research focus group represented the school's diverse whānau demographic population, including but not limited to ethnicity, occupation, years lived in the community and level of experience with and knowledge of the school's structure, policies, curriculum, staff and students.

Ethnicity represented by whānau focus group participants included European (*n* = 1), Pasifika (n = 1), Māori (*n* = 2) and Aotearoa New Zealand European (*n* = 3). All whānau focus group participants were biological parents of children in years 9 (*n* = 4) or 10 (*n* = 3); most were mothers (*n* = 6). Children represented by their whānau included both genders, with 3 females and 4 males. The sample included whānau of students across the spectrum of science interest and ability, from a year 10 student with learning difficulties to two years 9 and 10 students identified by teachers as at the top in their year groups for scientific talent based on student assessment scores and nature of science behaviour/skills demonstrated in the classroom. All whānau felt their sons and daughters had the potential to improve in both science engagement (including attitude) and performance (skills and content).

Whānau experience with and knowledge of the local community, the college, the science department and the Aotearoa New Zealand secondary science curriculum varied greatly and influenced the focus group discourse. Some were alumni, having grown up in the area and attended the secondary school. A recent Pasifika immigrant who had immigrated in 2014 was the whānau participant with the least community experience. Although 71% had been educated in the Aotearoa New Zealand secondary education system, it was under the former School Certificate programme. Therefore, none of the participants had first-hand experience as students with NCEA (introduced in 2002-2004) or the current six-level Aotearoa New Zealand Curriculum (2006). All lived and worked in the local community, holding one or more occupations such as dairy farmer, dressmaker, nurse, housewife or stay-at-home-mum. Some had prior training in previous fields or countries but were not currently practicing in their area of expertise, such as radiography or early childhood education.

Three whānau focus group participants had one or more older children who were currently attending or had recently graduated from the school; these whānau were quite familiar with school structures, policies, teachers and students. One participant had also served on the School Board of Trustees, obtaining first-hand experience with the development of the school's strategic aims and its recent progress (or lack thereof) in areas of cultural responsiveness, academic rigour, school-wide discipline and Te Tiriti o Waitangi principles of partnership, participation and protection. These three whānau could draw upon experiences of their older children and prior school interactions when answering focus group questions about current years 9 and 10 science classes. The remaining four whānau had either one (n = 2) or two children in years 10 and below at the college. Two were first-generation immigrants from other countries coping with language and/or cultural educational differences. The demographic diversity of whānau contributors provided differing perspectives, assisting me in gathering a more complete picture of how the whānau community viewed differentiated science teaching and learning.

Summary

In this chapter I introduced the setting within which my MMAR design and methods were carried out – the local community, school, teachers, students and whānau. I explained how my position as teacher and community member impacted my research design and methods, clarifying how my work aligned with both L. T. Smith's (2005) culturally responsive 'community-up' values for Indigenous research and Messiou and Ainscow's (2015) 'purposive community' approach to change from within rather than outside communities. Potential advantages and disadvantages to small schools and educational research within them were presented including the potential relevance of Strike's (2010) WITT approach to sustainable change.

I described my inclusive research participant invitation and selection process, detailing the demographics of those invited (all years 9 and 10 science students, teachers and whānau). I then explained how participants who voluntarily agreed to and engaged in the MMAR process provided a somewhat representative sample of the overall years 9 and 10 students' teachers, student and whānau community. Teachers' backgrounds, training, teaching experience, motivations and previous professional development in differentiated teaching and learning were presented to provide the contextual framework from which the MMAR developed within the school's science department. The ensuing Chapters 5-8 report on the: (a) rationale for and type of methods and instruments used in quantitative and qualitative data collection and analysis, (b) perspectives gathered from participants and (c) meta-inferences derived throughout my 6 phase MMAR cycle.

Chapter 5:
Diagnosing and Reconnaissance –
Quantitative Data Collection and Analysis

Titiro whakamuri, kōkiri whakamua

Look back and reflect so you can move forward.

Results are reported within Chapters 5-8 in sections that correspond to Ivankova's (2016) six MMAR phases employed in this research: *Diagnosing, Reconnaissance, Planning, Acting, Evaluating and Monitoring*. All results are synthesised from analyses of quantitative and qualitative data gathered from the following research instruments:

- years 9 and 10 student and teacher online surveys,
- student and whānau focus groups,
- teacher individual interviews,
- classroom observations,
- teacher planning documents,
- teacher collaborative discussions,
- student work samples and
- researcher field notes.

Figure 5.1 shows how Ivankova's individual MMAR phases guided my study, including which instruments were employed in each phase. For example, online surveys were used to collect quantitative data pre/post implementation of the differentiated unit in the *Reconnaissance* and *Evaluating* phases. The rationale for the selection of and modifications made to each instrument, as well as the specific details of the instrument implementation and analyses procedures, are reported by MMAR phase. Research results in each phase are then organised into subsections based on emerging themes that arose from mixed methods quantitative and qualitative descriptive analyses. Chapters 5 and 6 focus on the methods and findings of phases 1 and 2: *Diagnosing* and *Reconnaissance*.

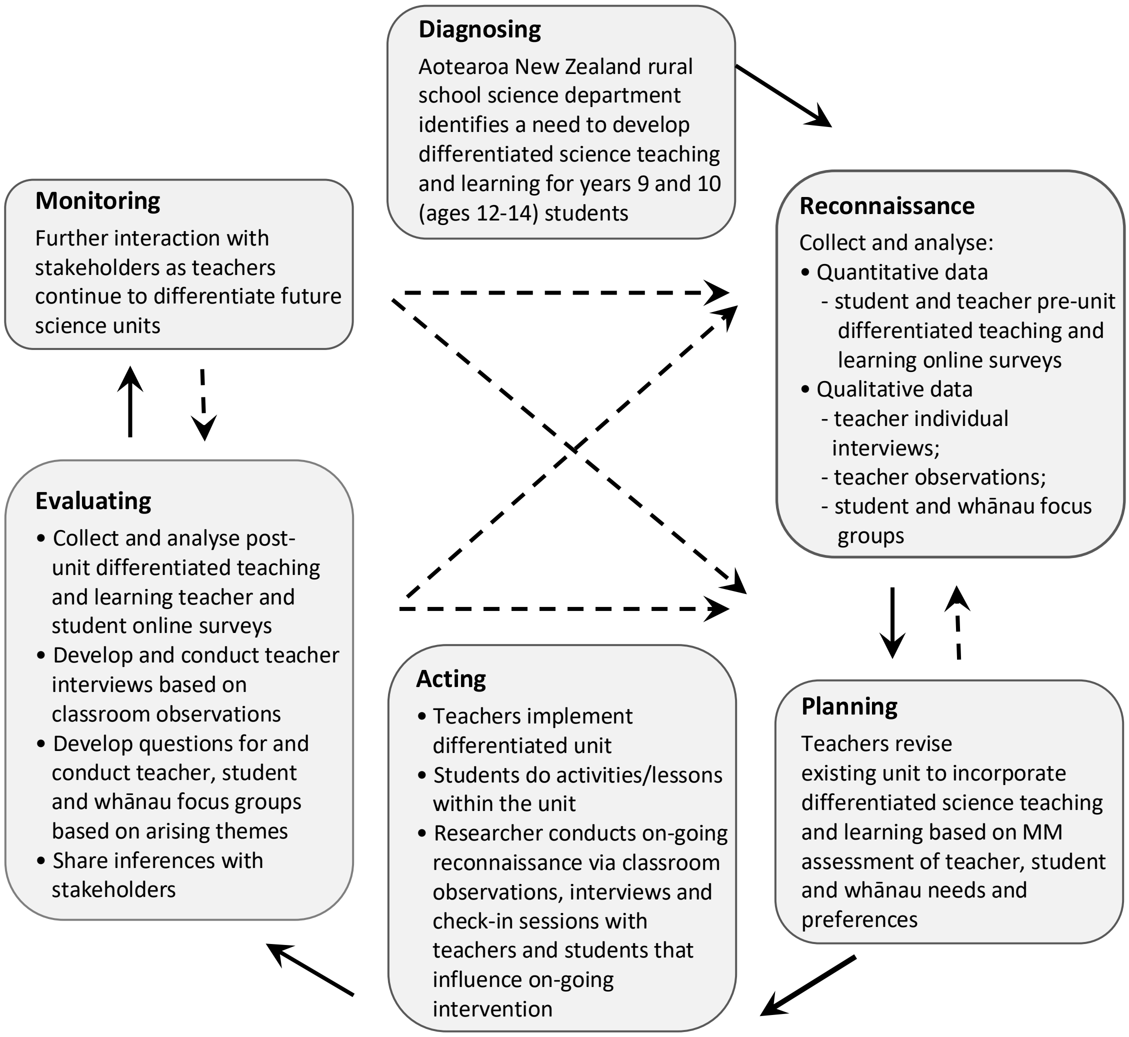


Figure 5.1: My differentiated science research instruments implemented by MMAR phase. Adapted from Ivankova (2015, p. 73) and used with permission of SAGE Publications.

Diagnosing

Prior to the development of my research, the school's science department – Alton, Sage and I – reflected upon existing instruction policies and techniques. We science teachers, through discussions with colleagues, students, whānau, the principal and the Board of Trustees, identified a professional need to develop differentiated science teaching and learning skills and pedagogy for instructing years 9 and 10 science classes. This topic was selected as a way to engage and meet the needs of all students, but specifically scientifically talented students who had reported a disinterest in early secondary science due to a lack of challenge and/or boredom. Differentiation was especially pertinent as new school management (2014) discontinued the Gifted and Talented Education (GATE) years 7-9 extension pull-out programme, for the following school year, asking teachers to differentiate in mixed-ability mainstream classrooms instead. In response to the change in provisions, several of the talented students' whānau were choosing to or considering transferring children to larger town schools with accelerated programmes for the 2015 school year. The science department chose to focus on professional growth in teacher differentiated teaching and learning within the department as a potential tool for increasing retention and engagement of not only these high-achieving students, but also to address the increasing diversity of years 9 and 10 science classes.

As described in Chapter 4, I prepared and submitted a study leave proposal to explore this topic that was accepted by both the school's Board of Trustees and the Ministry of Education for the 2015 school year. An essential component of the *Diagnosing* phase was examining Aotearoa New Zealand and international inclusive education and differentiated teaching and learning research (Ivankova, 2015). Findings from my literature analysis contributed to the selection of MMAR as the methodology for research as well as the formation of the overall study plan, purpose, objectives and research questions. My review of literature also informed research instrument development as no suitable research instruments existed in Aotearoa New Zealand or internationally to help me conduct a MMAR investigation into years 9 and 10 differentiated science teaching and learning from the perspectives of teachers, students and whānau.

I modified existing non-science differentiation tools to fit my research context. My literature review led to the use of quantitative surveys for the *Reconnaissance* and *Evaluating* phases that were grounded in Tomlinson's (1999, 2003, 2005, 2010) and Kanevsky's (2011; 2013) extensive differentiation research and had been developed and utilised in multiple previous studies (Kiley, 2011; Page, 2007; Alixa Rodriguez, 2012; Whipple, 2012). The qualitative classroom observation templates, teacher individual interview questions and student and whānau focus group schedules arose from evidence-based development in the fields of differentiation as well as scientific assessment (Fraser, Aldridge, & Adolphe, 2010; Helding & Fraser, 2006; Kanevsky, 2011a, 2013; Tomlinson, 2014). Additional strategies and modifications were developed and incorporated into these instruments in phases 3-6 as is distinctive of dynamic MMAR (Ivankova, 2015) and fitting with the pragmatic paradigm (R. B. Johnson & Gray, 2010; D. L. Morgan, 2014b). Only after consent was obtained from a representative sample of the community – 3 teachers, 39 students, and 7 whānau – did I transition to the next phase of research, fact-finding, also known as *Reconnaissance*.

Reconnaissance

The purpose of the *Reconnaissance* phase of this MMAR study was to investigate differentiated teaching and learning practices in years 9 and 10 science classrooms. The goal of the quantitative strand of this phase was to identify the value that years 9 and 10 teachers and students held for differentiated teaching and learning components, as well as how often teachers incorporated differentiation within the school's junior science (years 7-10) classroom practice. The goal of the qualitative strand of the *Reconnaissance* phase was to more fully understand the differentiated science teaching and learning survey responses by conducting classroom observations, teacher individual interviews and student and whānau focus groups. The rationale for integrating quantitative and qualitative methods at this study phase was to obtain validated meta-inferences to inform the development of a differentiated teaching and learning unit responsive to the unique needs of local years 9 and 10 science students.

An overview. *Reconnaissance* occurred throughout 2015, with all quantitative and qualitative data collection scheduled to occur at the end of the school year per teacher request following the commencement of senior student (years 11-13) study leave. As delineated in Chapter 3, I intended to embed mixed methodology in the *Reconnaissance* phase through an explanatory sequential QUAN → QUAL research design that would allow me to more fully understand teacher, student and whānau perspectives of science differentiated teaching and learning. I planned to extend the depth and complexity of quantitative online surveys through qualitative individual and focus group interviews and classroom observations.

The QUAN → QUAL sequential strategy was employed as intended for my student data collection and analysis protocol. However, unexpected school changes to the NCEA reporting deadlines and end-of-year teaching schedule resulted in an increased workload for participating teachers. As a result, Alton and Turin completed their online surveys only after years 9 and 10 science classes had transitioned to end-of-year education outside the classroom (EOTC) activities, making it impossible for me to conduct classroom observations and student/whānau groups post-teacher survey. Eliminating classroom observations and focus groups from my research design would have greatly impacted the rigour and persuasiveness (Ivankova, 2015) of my MMAR study. Therefore, in alignment with the responsive nature of educational action research in a real school setting (Elliott, 1991; Ivankova, 2015; Mertler, 2014) and cultural research values of aroha ki te tangata and titiro, whakarongo, kōrero (Cram, 2001; L. T. Smith, 1999), I revised my research design for teacher data collection and analysis from a strict explanatory sequential format to a hybrid of sequential and concurrent explanatory QUAN/QUAL data collection and analysis. Figure 5.2 illustrates my data collection in the chronological order of implementation. Sage's survey and the student online surveys were completed first, followed by classroom observations, teacher individual interviews, student focus group interviews, additional classroom observations, whānau focus group interviews and Alton's and Turin's online surveys.

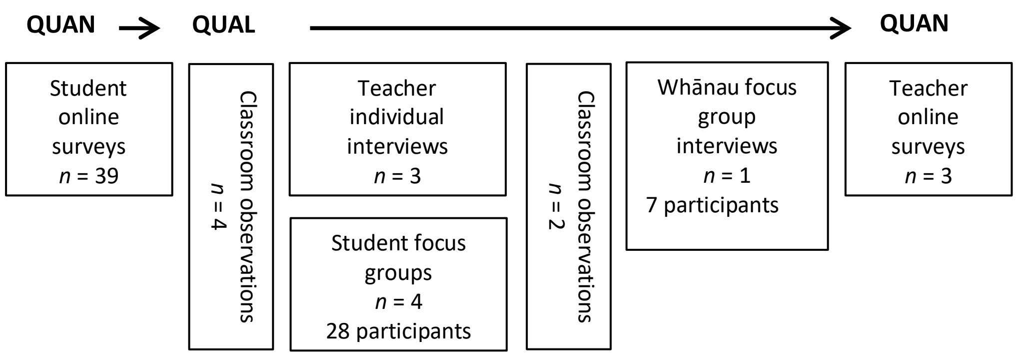


Figure 5.2: ***Reconnaissance*** **MM data collection and analysis in response to teacher need.**

Due to the large amounts of data collected and analysed in the *Reconnaissance* phase, and to facilitate thesis readability and clarity of discussion, I have chosen to report on the quantitative and qualitative methods and findings in two separate chapters. The rationale for my selection of the unique *Reconnaissance* quantitative instruments utilised in this study, their development, specific research data collection/analysis procedures and findings are discussed in the following sections of this chapter. I describe the selection of the *Reconnaissance* qualitative instruments utilised in this study, their development, specific research data collection/analysis procedures and findings in Chapter 6. Quantitative and qualitative integration strategies, derived meta-inferences and implications for the *Planning* and *Implementation* phases are then discussed in Chapter 7.

Quantitative research instruments. This section describes my development and use of online surveys to understand teacher and student perceptions of current differentiated science teaching and learning practices. Because of the absence of research investigating science differentiation from the perspectives of teachers, students and whānau, I describe the process of choosing from a number of evidence-based science and non-science resources when selecting the format and questions for the surveys. The advantages and disadvantages of surveys are integrated throughout the discussion.

Teacher and student differentiated instruction attitudes and integration online surveys. Creswell (2015) defines survey research as a "a form of quantitative research in which the investigator identifies the sample and the population, collects data through questionnaires or interviews, and draws conclusions or makes inferences" (p. 409) in regards to research questions. Surveys have been proven to be a time and cost-efficient primary data collection for systemically gathering, comparing, and contrasting current perspectives, attitudes and self-reporting of behaviour. When implemented judiciously, they provide insightful glimpses into the thoughts and opinions of a wider range of participants than is possible in individual interviews (Creswell, 2015a; Fink, 2017; Fowler, 2014; Gorard & Taylor, 2004; Henning, 2009).

Longitudinal pre/post surveys were employed in this study to measure the impact that teachers' differentiation of the curriculum in response to community input had on student learning (Creswell, 2015a; Edmonds & Kennedy, 2013; D. L. Morgan, 2014a). *Reconnaissance* surveys assessed existing differentiated teaching and learning practices in Term 4, 2015 and were reinstituted in the *Evaluating* phase of May 2016 to measure changes in stakeholder differentiated teaching and learning perspective post *Acting* phase. Because survey responses can be limited or altered by the questions asked, Henning's (2009) steps to reduce researcher bias were followed: planning, piloting (with revisions made based on feedback), administering, analysing and reflecting.

Teacher and student quantitative surveys (Appendices I & J) were modified in content and context from Whipple's (2012) *Teacher Survey on Differentiated Instruction*. Whipple's survey was grounded in the differentiation research of Tomlinson and modified from similar teacher reflection instruments previously used by Tomlinson and Allan (2000) and Page (2007) to help teachers assess and develop differentiated teaching and learning opportunities. A limitation of my use of these surveys is their lack of reliability testing. However, I chose to use them for my research because the surveys were accepted by practitioners and leading researchers in the field of differentiation as quality tools for evaluating differentiated teaching and learning practice (Kiley, 2011; Page, 2007; Tomlinson & Allan, 2000; Whipple, 2012).

Examples of Te Tiriti o Waitangi responsive modifications that I made to the survey included greater cultural awareness and incorporation of Māori dimensions such as the Tātaiako cultural competencies: ako, manaakitanga, tangata whenuatanga, whanaungatanga, and wānanga (Ministry of Education, 2011). Relevant nature of science components of the Aotearoa New Zealand Science Curriculum (2007) and science capabilities (Ministry of Education, 2015b) were incorporated, such as 'require learners to use and critique evidence' or 'require students to gather and interpret data representations.'

I utilised Hopgood and Ormsby's (2011) recommendation of the web-based platform of SurveyMonkey for survey design to facilitate feasible online data collection and analysis of both teacher and student differentiated teaching and learning input. In-person and web-based support for teacher and student participants were provided to maintain consistent survey conditions. Administering student surveys in the school's computer room also enabled me to provide verbal clarification of any ambiguous statements or survey functions (such as drop-down menus) that might be unclear to individual students. Survey completion time was approximately 20 minutes for teachers and 30 minutes for students.

Teacher and student *Differentiated Instruction Attitudes and Integration Surveys* (Appendices I & J) used in this research were first trialled with cultural advisors, education researchers and practicing Aotearoa New Zealand science teachers and local students. Minor revisions to the surveys were made based on trial participant, Massey University Human Ethics Committee and PhD supervision feedback including greater cultural sensitivity, clarification of survey directions, revision of ambiguous statements, division of compound questions and adjustment to the order of the Likert scale responses. Due to concerns over the length of the trial survey, I followed Kiley's (2011) exemplar of three parallel columns for level of importance, differentiated teaching and learning component and level of use.

Although the majority of the survey response format was quantitative in nature, the teacher survey began with some descriptive questions probing teachers' current understanding of differentiated instruction. Each participating teacher was asked to define differentiation, rate knowledge and confidence in using it, and explain how, if at all, s/he differentiated with years 9 and 10 science classes.

The student survey began with an introduction to differentiated teaching and learning and a series of 13 science-related attitude questions derived from Helding and Fraser's (2006) *Modified Attitude Scale*. This attitude scale, also called the *Enjoyment of Science Lessons Attitude Scale* in more recent literature (Helding & Fraser, 2013), is derived from Fraser's (1981) *Test of Science-Related Attitudes* (TOSRA) and subsequent education research (Aldridge, Fraser, & Huang, 1999; Fraser et al., 2010; Fraser, Tobin, & McRobbie, 2012; Helding & Fraser, 2006, 2013). The TOSRA is one of the most widely used instruments to determine students' attitudes toward science (Fraser et al., 2010). The TOSRA has been validated both in Australia (1,337 students) and the United States (546 students) for effectively assessing science-related attitudes of intermediate and early secondary science students (Helding & Fraser, 2013). TOSRA reliability has been calculated with a Cronbach alpha coefficient of 0.81 when using individual students as the analysis unit and 0.93 when analysing class means (Helding & Fraser, 2013). Translated versions of the TOSRA have also been used and validated in Singapore (Wong & Fraser, 1996), Taiwan (Aldridge et al., 1999) Korea (Kim, Fisher, & Fraser, 2000) and Indonesia (Fraser et al., 2010).

The attitude scale assesses the “extent to which students consider that their science lessons are enjoyable and look forward to them” (Helding & Fraser, 2013, p. 7) and was selected for use in this study for its ability to measure student enjoyment of secondary science teaching and learning. The attitude questions asked students to consider their overall science experience at the school and respond to individual statements, such as ‘I look forward to science classes’ or ‘Science is one of the most interesting school subjects’ with ‘Disagree’, ‘Not Sure’ or ‘Agree’. I coded and collated all student responses for analysis of learner attitude toward science as well as indicators of classroom environment.

Figure 5.3 shows the statements of the attitude section of the student survey. Statements 1-11 originate from Helding and Fraser’s work (2006). I added questions 12 and 13 to explore student perceptions of the relevance of science to culture and whānau within an Aotearoa New Zealand context.

1. I look forward to science lessons.
2. Science lessons are fun.
3. I enjoy the activities we do in science.
4. Science is one of the most interesting school subjects.
5. I want to find out more about the world in which we live.
6. Finding out about new things is important.
7. I enjoy science lessons in this class.
8. I like talking to my friends about what we do in science.
9. We should have more periods of science each week.
10. I feel satisfied after a science lesson.
11. Science is relevant to my life.
12. Science is relevant to my culture.
13. Science is relevant to my whānau.

Figure 5.3: Science related attitude question section of the student survey.

The second section of both the teacher and student survey was divided into four major categories: *awareness of student differences, content, process* and *product*. These categories and the clarifying statements below them were chosen based on critical components of differentiated instruction identified in research conducted by Bevan-Brown (2011); Kanevsky (2011a); Maker and Schiever (2010); Riley (2011) and Tomlinson and Strickland (2005). Teachers and students were asked to rate the components of differentiated science instruction on a 5-point scale across two dimensions:

- Importance:
  (A) Not important; (B) Somewhat important; (C) Neutral; (D) Important; (E) Essential and
- Usage (incidence):
  (1) Never/Hardly ever; (2) Sometimes/Have done a few times; (3) Frequently;
  (4) Do intentionally and often; (5) Not sure.

On the student survey, 'Do Intentionally and Often' was removed and replaced with 'Usually'. Wording was simplified on student questionnaires to facilitate reading comprehension and increase the reliability of student responses. Figure 5.4 shows some of the question modifications made to the student content section of the survey to aid in readability. For example, while teachers were asked if the content they taught was 'Embedded with methods of inquiry: emulating the work of actual scientists,' students were queried as to whether their science classes 'Encourage us to think and question like actual scientists.'

Teacher *The Content I Teach is…*	**Student** *The Topics We Learn in Science…*
• Based on broad-based themes, issues and problems • Planned, comprehensive, related and mutually reinforcing • Gender balanced and inclusive • Embedded with methods of inquiry: emulating the work of actual scientists • Grounded on clearly articulated objectives: Students are cognizant of what they should know, understand and be able to do	• Have big themes that deal with important issues and problems • Seem well-planned • Encourage both genders (male and female) to succeed • Encourage us to think and question like actual scientists • Have clear objectives: we are aware of what we need to know, understand and be able to do

Figure 5.4: Contrast of wording between teacher and student questions of survey.

All participating teachers were asked to reflect on how often they incorporated differentiated teaching and learning components in their current teaching practice with years 9 and/or 10 science students. To enable the inclusion of 2016 years 9 and 10 student stakeholder voice into the collaborative teacher planning stage of MMAR cycle, *Reconnaissance* surveys were distributed at the end of 2015 to existing years 8 and 9 students. Participating students, therefore, were asked to consider the incorporation of differentiated teaching and learning components throughout their science learning experience at the school, which for 90% of the contributing learners (n = 35) began in year 7. The participating students had taken mandatory science classes several times a week for a range of 1-3 years (depending on when individual students joined the school), under the instruction of a variety of science teachers.

After piloting, minor modifications were made to these surveys before they were administered to both teachers and students again in the *Evaluating* segment of study. The revised *Evaluating* surveys served to monitor the effects of the *Planning* and *Acting* phases, providing data to analyse, compare and contrast stakeholders' perspectives pre- and post-study regarding the relevance and effectiveness of differentiated science teaching and learning both within the science department and across the wider school and community. Modifications made to teacher and student surveys for the *Evaluating* phase are shown in Appendix K and discussed, along with analysis procedures, in Chapter 8.

Quantitative analysis. The survey analysis and interpretation followed Creswell's (2015a) steps:

- preparing data for use in statistical programmes;
- conducting statistical data analysis;
- reporting and describing the results through visual representations such as tables and
- interpreting the findings' applications in relation to the study itself as well as existing literature and general society.

My research incorporated a two-cycle strategy of first cycle coding and second cycle pattern coding. The first cycle coding strategies included descriptive coding, process coding and evaluation coding (Miles et al., 2014). Responses provided for level of importance and usage (incidence) of key components of differentiated teaching and learning and student attitude toward science were analysed. Responses were coded numerically and the mean (*M)* calculated for each item to allow for comparison of similarities and differences in student and teacher perceptions in the *Reconnaissance* and *Acting* phases and pre/post comparisons in the *Evaluating* phase. Conversion of ordinal Likert scale survey responses to scalar data for mean comparison is common in both educational and medical research (Jamieson, 2004; Machebe, Ezegbe, & Onuoha, 2017; Rickards, Magee, & Artino, 2012). However, the use of means to represent and compare participant survey response poses limitations including:

- difficulty in measuring the differences in participants' judgement – it is unlikely that spacing between Likert scale judgements of 'not important,' 'somewhat important' and 'neutral' would be truly identical (Jamieson, 2004) and
- the potential of any measure of central tendency to hide distribution characteristics, including the exclusion of outliers and (G. Sullivan & Artino, 2013).

To address these challenges, I conducted frequency analysis to show the number and percentage of responses. Frequency tables for the *Reconnaissance* and *Evaluating* phases are included in Appendix L in an effort to provide transparency for research as recommended by G. Sullivan and

Artino (2013). As Appendix L shows, the frequency data confirms the differentiation values and usage indicated by mean analysis of teacher and student survey responses.

To begin quantitative analysis, I first prepared the survey data. This was facilitated in large part by the organisational framework of how I established the initial surveys in Survey Monkey. Participant responses were exported from Survey Monkey in two formats: (a) individual responses with demographic information connected and (b) collated summary information, which provided both overall participant percentage response to each question as well as the number of participants providing the response. All teacher and student survey responses were exported from Survey Monkey as SPV [Statistical Package for the Social Sciences (SPSS) Analysis Output] files. Upon importing them into SPSS, I prepared the data for quantitative descriptive statistical analysis. Due to the limited number of *Reconnaissance* participants, the inferential and more advanced statistical tests I had considered early in the study design were no longer appropriate.

The 3 participating *Reconnaissance* teachers completed all 139 survey questions; 32/39 *Reconnaissance* students fully completed their 135 survey questions. Five of the incomplete student surveys were missing 1-3 responses and were included in analysis calculations. The remaining two incomplete student surveys were missing over 30 answers. The two students with 30+ answers missing answers were removed from both the *Reconnaissance* and *Evaluating* quantitative survey analysis as they also had over 30 questions missing on their post-surveys. However, those students whose quantitative survey responses were excluded from quantitative analysis were included in qualitative analyses as they provided specific clarification of classroom differentiated teaching and learning classroom happenings during their pre/post group interviews.

The responses to the surveys' qualitative questions asking (a) teachers to define differentiated instruction, explain if/how they differentiate and share clarifications regarding survey answers and (b) students to provide further clarification comments or suggestions regarding science class and their ability to learn and challenge themselves were also exported from Survey Monkey and imported into SPSS. Teacher and student responses were then analysed in accordance to qualitative constant comparison analysis (Leech & Onwuegbuzie, 2007) further detailed in the qualitative analysis section of Chapter 6.

Quantitative data preparation involved coding student science attitude responses on a scale of 0-2: 0 – Disagree; 1 – Not sure; 2 – Agree. The Likert scale responses for teacher and student ranking of the importance of differentiated components were likewise coded: 1 – Not important; 2 – Somewhat important; 3 – Neutral; 4 – Important; 5 – Essential. The usage (incidence) scale was also coded (1-5): 1 – Hardly ever/Never; 2 – Sometimes; 3 – Frequently; 4 – Usually; 5 – Not sure. Because 'not sure' responses for usage did not meet the ordinal pattern of the other Likert responses, they were excluded from mean analysis calculations. Therefore, quantitative means presented in this thesis are based on two similar, but not identical, scale ranges, 1.00-5.00 for importance and 1.00-4.00 for usage.

Mean comparison analysis was chosen as a pragmatic way to compare and share participating teachers' and students' views on the value and usage of differentiation components in science classroom practice. Initial groupings of quantitative data segments resulted in:

- differentiated teaching and learning components of high or low value to teachers, students or both;
- differentiated teaching and learning components that teachers, students or both viewed as incorporated most or least often in science classroom practice;
- similar views of differentiation among or between teachers and students and
- differing views of differentiation among or between teachers and students.

Quantitative *Reconnaissance* findings reported in this chapter stem from those differentiated teaching and learning components perceived by science teachers and/or students as having:

- *high* value and *high* usage – providing me with insight into effective differentiation in existing science classroom teaching and learning.
- *low* value and *low* usage – exposing differentiation that, while supported by the literature, was currently of least value to the community (and therefore, irrelevant to the aims/purposes of MMAR).
- *high* value and *low* usage – revealing potential teaching and learning curriculum for increased science differentiation.

In selecting the above categories, I was able to narrow down the plethora of science differentiation options to a feasible few (Kanevsky, 2011a), focusing on those viewed to be most relevant to my research community as explained in the following section of this chapter.

Quantitative findings. My discussion of the *Reconnaissance* quantitative results begins by introducing the differentiated quantitative survey data that teachers and students reported as:

- already happening in science classrooms – high value and high usage;
- of least value or use to the community – low value and low usage and
- having most potential for science differentiation growth – high value and low usage.

Similarities and differences among and/or between teachers' and students' perspectives are discussed when applicable. Identification of the differentiated themes that emerged from the pattern coding of these quantitative data such as authenticity, relevance, challenge or variety is integrated throughout the findings' discussion. These themes are then further expanded, using supporting qualitative data, in the qualitative results of Chapter 6.

Teachers and students always reported differentiated strategies as being more important than actually occurring in existing science classroom teaching and learning. Teachers' response means for reported importance and usage were usually higher than student response means. Table 5.1 shows the results for the differentiated components reported by participating teachers or students of highest value and usage. In contrast, Table 5.2 displays the differentiated areas of lowest value and usage to teachers and students. Table 5.3 presents the survey results of highest value and lowest usage. Quantitative data analysis did not indicate any low value – high usage difference.

Differentiation valued and used in existing science classrooms. As shown in Table 5.1 both teachers and students cited science differentiated teaching and learning qualities in existing science classroom practice. These qualities were reported by teachers as occurring across all four dimensions of potential differentiation: awareness, content, process and product. Students reported strengths in the areas of awareness, content and product, but not process.

Participating teachers reported (a) awareness of individual students' strengths and talents, (b) ability to plan comprehensive, related and mutually enforcing content and (c) use of specific criteria in product evaluation as the differentiation strategies most commonly used in their science classroom (usage M = 4.00). Of most importance to teachers were (a) differentiation through a variety of activities and (b) product evaluation based on specific criteria (value M = 4.67).

Students rated encouragement of both genders to succeed as the differentiation component most likely to occur (M = 3.09) and of most importance (M = 4.08). Like their teachers, student participants reported high value and incidence of teacher awareness of students' interests (value M = 3.76, usage M = 2.78), strengths and talents (value M = 3.54, usage M = 2.74). Students also positively reported on teachers' use of (a) variety in options (value *M* = 3.89, usage *M* = 2.85) and (b) marking schedules with clear expectations (value *M* = 3.51, usage *M* = 2.72) for product assessment.

Table 5.1: *Reconnaissance* Survey Results: Differentiation of Highest Value and Usage in Existing Science Classroom Teaching and Learning

Teachers' Perspectives	**Value Mean *(1.00-5.00)***	**Usage Mean *(1.00-4.00)***
Awareness		
Know individual student's interests	4.33	3.67
Aware of individual student's strengths and talents	4.00	4.00
Know student's life situations and how they may impact learning	4.00	3.67
Content		
Planned, comprehensive, related and mutually enforcing	4.33	4.00
Process		
Support a variety of activities including group and individual work	4.67	3.67
Incorporate a variety of instruction modes	4.33	3.67
Provide tasks that to extend understanding	4.33	3.67
Product		
Are evaluated appropriately with specific criteria	4.67	4.00

Students' Perspectives	**Value Mean *(1.00-5.00)***	**Usage Mean *(1.00-4.00)***
Awareness		
My science teachers know what I know about the topic	3.92	2.84
My science teachers know what I am interested in	3.76	2.78
My science teachers are aware of my strengths and talents	3.54	2.74
Content		
Encourage both genders to succeed	4.08	3.09
Have clear learning objectives	3.92	2.79
Process		
No ratings of high value and high usage for process		
Product		
Use a variety of options: tests, labs, projects, reports	3.89	2.85
Have a marking schedule with clear expectations	3.51	2.72

Students, unlike teachers, reported clear content learning objectives (value *M* = 3.92, usage *M* = 2.79) and teacher awareness of student prior knowledge (value *M* = 3.92, usage *M* = 2.84) as differentiation components that were both important and frequently occurring. Teachers, unlike students, reported variety in process activities (value *M* = 4.67, usage *M* = 3.67) and instruction modes (value *M* = 4.33, usage *M* = 3.67) as essential and often occurring.

Teachers, rather than students, reported a high importance in and provision for classroom tasks that extended student understanding (value $M = 4.33$, usage $M = 3.67$).

Differentiation least valued and used in existing science classrooms. Individual survey participants did at times rank specific differentiated teaching and learning components as having little importance. Mean score analysis of quantitative survey responses, however, revealed that collectively, neither teachers nor students viewed any differentiated components as unimportant. As such, the findings in Table 5.2 are referred to as lowest and low importance only in relation to other survey responses in order to prioritise differentiated teaching and learning values for subsequent MMAR *Planning* and *Implementation* phases and should not be interpreted as being unimportant or of no value to teachers and students. Analysis of usage means, on the other hand, did reflect a low incorporation of some differentiated components in existing science classrooms.

Table 5.2 displays the differentiated teaching and learning components that participating teachers and students identified as having lowest value and/or usage in existing science classroom practice. Teacher responses reflected lowest value and usage of differentiation components in the areas of process and product. Teachers considered the least important ($M = 3.33$) differentiation components to be:

- connections to scientists – 'mirroring scientists' roles/skills' and 'incorporating scientific experts',
- authenticity of product – 'designed for audience beyond teacher' and
- pacing – 'compacting curriculum'.

Similarly, teachers reported processes that mirrored scientists' roles/skills or incorporated 'real-world' service opportunities as differentiation least likely to occur in their classrooms ($M = 1.33$).

Student responses emphasised affect (awareness of students' needs), reflected in what students reported as a disinterest in and low incidence of teachers knowing and linking student's 'cultural background' and 'life outside of school' to classwork (value: $2.11 \geq M < 2.65$; usage: $1.48 \geq M \leq 1.75$). As Table 5.1 indicates, student responses seemed to contradict teachers reported high value in and strong knowledge of students' life situations (value: $M = 4.00$; knowledge: $M = 3.67$). Indeed, collectively, teachers did not rate any aspects of affect (awareness of students' needs) to be of low value or low usage. Students, in contrast to teachers, did not rate any aspects of process or product as of low value or usage. Students and teachers alike reported a somewhat low value and usage of Tātaiako in classroom content or process (students' value of Tātaiako content: M = 2.95, usage: M = 2.19; teachers' value of *Tātaiako* process: M = 3.67; usage: 2.33).

Table 5.2: *Reconnaissance* Survey Results: Differentiation of Lowest Value and Usage in Existing Science Classroom Teaching and Learning

Teachers' Perspectives		
	Value Mean *(1.00-5.00)*	**Usage Mean *(1.00-4.00)***
Awareness		
No ratings of low value and usage for awareness		
Content		
Embedded with inquiry	3.67	1.67
Process		
Adjust for learner needs with compacting	3.33	2.00
Are real, mirroring scientists' roles and skills	3.33	1.33
Incorporate scientific experts/mentorship	3.33	2.00
Include service opportunity	3.67	1.33
Utilise student personal goal setting	3.67	1.67
Are inclusive of Tātaiako	3.67	2.33
Product		
Are designed for audience beyond teacher	3.33	2.33
Emulate real science: peer review/debate	3.67	2.00
Are transformational: shifting students from the role of 'consumers' to 'producers' of knowledge	3.67	2.00
Students' Perspectives		
	Value Mean *(1.00-5.00)*	**Usage Mean *(1.00-4.00)***
Awareness		
My science teachers know about my life outside school	2.11	1.55
My science teachers consider my life outside of school in classroom teaching and learning	2.32	1.73
My science teachers link my cultural background into our work	2.41	1.48
My teachers know my cultural background	2.65	1.75
Content		
Are inclusive of Tātaiako	2.95	2.19
Process		
No ratings of low value and usage for process		
Product		
No ratings of low value and usage for product		

Differentiation viewed as important but seldom used in existing science classrooms. As shown in Table 5.3, both teachers and students cited differentiated science teaching and learning strategies that they felt were important but seldom occurred in existing science classroom practice. Teachers reported potential areas for differentiated curriculum development in content, process and product. Students stated room for growth in the areas of awareness, process and product.

Table 5.3 highlights that teachers' and students' responses revealed shared perspectives on the importance of and absence of three differentiated science teaching and learning components in current science classroom teaching and learning:

- pre-assessment of student readiness at start of new unit or topic;
- authenticity - emulating real science, connecting students' new ideas to the current and historical body of science knowledge and
- challenge - through product, process and awareness.

Teachers, unlike students, cited the following areas of differentiation that they valued, but seldom used in their classrooms:

- student metacognitive development, including self-evaluation and
- bicultural inclusion - Māori dimensions in classroom content.

Students identified three different areas of differentiation as valuable but rarely occurring in their classrooms:

- awareness and accommodation of student learning difficulties or difficulties,
- variety in learning processes beyond bookwork and
- collaboration opportunities among peers.

Interestingly, while participating teachers also identified awareness and accommodation of student learning difficulties, variety of process and student collaboration as being of high importance, the teachers, in contrast to students, reported that they incorporated them often in classroom practice (see contrast in Tables 5.1 and 5.3).

Qualitative data collection and analysis provided me with a fuller understanding of the apparent conflict between teacher and student perspectives on classroom implementation of differentiation that addressed students' learning difficulties, variety in learning processes and student peer collaboration opportunities. These qualitative findings are explained in the next chapter.

Table 5.3: *Reconnaissance* Survey Results: Differentiation of High Value and Low Usage in Existing Science Classroom Teaching and Learning

Teachers' Perspectives		
Awareness	**Value Mean *(1.00-5.00)***	**Usage Mean *(1.00-4.00)***
No ratings of high value and low usage for awareness		
Content		
Inclusive of Māori dimensions	4.33	2.33
Process		
Stimulate higher levels of thinking	4.67	2.67
Are metacognitive - allowing students to reflect upon thinking and learning	4.00	1.67
Pre-assess student readiness to adjust unit	4.00	2.00
Product		
Emulate real science: challenging students to connect new ideas to current and historical scientific knowledge	4.33	2.33
Include student self-evaluation	4.00	2.00

Students' Perspectives		
Awareness	**Value Mean *(1.00-5.00)***	**Usage Mean *(1.00-4.00)***
My science teachers challenge me to grow and excel	3.97	2.53
My science teachers know the areas of my learning difficulties	3.89	2.35
My science teachers address my learning disabilities	3.81	2.15
Content		
No ratings of high value and low usage for content		
Process		
Pre-testing knowledge	4.03	2.53
Use many different ways to learn: not just reading from a book	4.03	2.44
Challenge us to discover and problem-solve	3.84	2.35
Allow us to be in different groups based on our interests and needs	3.81	2.27
Product		
Encourage us to present ideas in a variety of ways	4.03	2.64
Challenge existing ideas	3.89	2.34
Use new and real scientific techniques	3.86	2.47

Summary

In this chapter I began with an overview of my quantitative and qualitative data collection instruments implemented by MMAR phase (Figure 5.1). I then explained the rationale behind the decisions made and procedures undertaken in the *Diagnosing* phase. I next provided an overview of the *Reconnaissance* phase, which sought to investigate differentiated teaching and learning practices in years 9 and 10 science classrooms from the perspectives of science teachers, students and whānau through quantitative and qualitative data collection and analysis (Figure 5.2). Goals for each data collection strand were described: (a) quantitative – to identify the value that years 9 and 10 teachers and students held for differentiated teaching and learning components, as well as how often teachers incorporated differentiation within the school's junior science (years 7-10) classroom practice and (b) qualitative – to more fully understand the differentiated science teaching and learning survey responses.

An explanation of the rationale for the procedures I used when selecting, developing and analysing the *Reconnaissance* online surveys was followed by a description of *Reconnaissance* quantitative findings. Quantitative *Reconnaissance* findings reported in this chapter stemmed from those differentiated teaching and learning strategies ranked by science teachers and/or students as having: (a) *high* value and *high* usage (Table 5.1), (b) *low* value and *low* usage (Table 5.2), or (c) *high* value and *low* usage (Table 5.3). The differentiated strategies reported by teachers and/or students of high value and low usage were identified as having most potential to improve teachers' ability to meet learner need through community-guided MMAR change and consisted of:

- pre-assessment of student readiness,
- authenticity of content and process (emulating real science skills),
- accommodation of student need particularly for those requiring extra support (students with learning difficulties) and challenge (scientific talented students),
- facilitation of student metacognitive growth,
- inclusion of bicultural teaching and learning strategies,
- variety of learning process and
- opportunities for student peer collaboration.

These strategies highlighted the teacher and student perception that science teachers could better meet diverse learners' needs through creating a culturally-inclusive learning environment that differentiated to provide learners with appropriate, authentic, challenging learning experiences in response to on-going assessment of student readiness. In the following chapter, I describe my *Reconnaissance* qualitative data collection, analysis and findings which served to further probe and more fully understand teacher and student quantitative perspectives on what an effective science teaching and learning environment was and how teachers could better foster it. I also share the perspectives of whānau on how teachers might differentiate in the *Planning* and *Acting* phases to improve existing classroom practice to better meet the diverse needs of years 9 and 10 students.

Chapter 6:

Reconnaissance – Qualitative Data Collection and Analysis

Nā te whakarongo me te titiro ka puta mai te kōrero.

Through looking and listening we gain wisdom.

As introduced in Chapter 5, the goal of the qualitative strand of the *Reconnaissance* phase was to more fully understand the differentiated science teaching and learning survey responses by conducting classroom observations, teacher individual interviews and student and whānau focus groups. The rationale for integrating quantitative and qualitative methods at this study phase was to obtain validated meta-inferences to inform the development of a differentiated teaching and learning unit responsive to the unique needs of current years 9 and 10 science students. In this chapter, I describe the rationale for and procedures utilised in *Reconnaissance* qualitative data collection and analysis. Findings gained from the qualitative instruments are also shared. Meta-inferences derived from the integration of qualitative and quantitative findings are then discussed, along with their implications for the *Planning* and *Acting* phases, in Chapter 7.

Qualitative research instruments

As classroom observation was the first (chronologically) qualitative data collection tool employed in this study, I begin with an explanation of its selection, development, implementation and analysis. I then give my reasons for selecting qualitative interviewing as a method of data collection and detail the specific one-on-one and group interview techniques employed in my study. I discuss the advantages of using observations and interviews for qualitative data collection and analysis, as well as how I managed potential disadvantages and/or limitations.

Classroom observations. Merriam and Tisdell (2016) note that all living creatures are natural observers of the world around them. Observation is how we "make sense of our world" (p. 138) and determine our future interactions in it. Merriam and Tisdell (2016) distinguish research observation from the routine, subconscious and unsystematic observations present in our daily lives. They declare observation a valuable qualitative research tool with the potential to produce trustworthy results when it is (a) systematic (b) "addresses a specific research question" (p. 138) and (c) "is subject to checks and balances" (p. 138).

Patton (2015) also supports the merit of qualitative observation, citing several benefits of direct observation in the field for qualitative research:

- observations allow researchers to witness research contexts first-hand rather than assume they already know what is happening;
- direct observation enables researchers to be “better able to understand and capture the context within which people interact, for understanding context is essential to a holistic perspective” (pp. 331-332) and
- observations have the potential to extend the limited perspective of interviews or focus groups, providing the chance to learn or witness things that might not come up in an interview as well as to develop an empathetic, rather than merely intellectual understanding, of what it “feels like to be there, in that place, doing those things, with those people” (p. 334).

Patton’s empathetic research approach to observation aligns with Tolich’s (2001) call for a unique approach to research in Aotearoa New Zealand and titiro*,* whakarongo . . . kōrero (Cram, 2001; L. T. Smith, 1999).

In educational research, classroom observations have two key advantages as they: (a) allow the researcher to gather actual teacher and student behaviour rather than rely on participants to report on their perceptions and (b) enable the researcher to see some things that the teachers might not be able to report on themselves (Creswell, 2015b; Mertler, 2014; Schmuck, 1997). Accordingly, the advantages of classroom observations for this MMAR study were that they allowed insight into teachers’ and students’ perceptions of differentiation in the classroom and allowed an observer’s fresh perspective on classroom routines and protocol (Patton, 2015) that the teachers or students might not recognise as hindering or helping differentiation.

Critics of observation as a qualitative data-gathering strategy argue that human perception is unreliable, selective and subjective (Merriam & Tisdell, 2016). However, research observation advocates argue (Merriam & Tisdell, 2016; Patton, 2015) that focused attention, writing descriptively, detailed field notes, practice in separating details from trivia, using “systematic methods to validate and triangulate” (Patton, 2015, p. 331) and reporting the strengths and limitations of the observer’s perspectives increases the trustworthiness of qualitative observations. As such, I attempted to incorporate all of these practices in my design and implementation of classroom observations.

I chose to utilise the format of semi-structured observing (Creswell, 2015a; Hubbard & Power, 2003) of differentiated teaching and learning strategies. Semi-structured observing involves engaging in "brief but intense periods of [both] observation and note-taking" (Mertler, 2014, p. 127). Semi-structured observations enabled:

- my focus to flow from one event to another,
- separation of detail from trivia and
- interesting phenomena to arise (Merriam & Tisdell, 2016; Mertler, 2014; Patton, 2015).

Each participating teacher was observed twice while teaching a 60-minute year 9 and/or year 10 class during the *Reconnaissance* phase at pre-arranged times determined by the teachers [aroha ki te tangata (Cram, 2001; L. T. Smith, 1999)].

Two limitations of my observations were: (a) an inability for me to observe all classroom happenings at once (A. P. Johnson, 2008) and (b) the influence of my presence on the behaviour of teachers' and students' normal day-to-day interactions (Mertler, 2014). To overcome the first limitation, I placed observational emphasis on teachers' actions and interactions with students; this aligned with my MMAR purpose of meeting the needs of years 9 and 10 science students through developing teacher practice in science differentiated teaching and learning. My position as a practitioner-researcher assisted me in addressing the second limitation, as my presence in the science classroom was not unusual due to my teaching position at the school. Furthermore, I informed all students in person ahead of time of the objectives for my classroom visits. To attend to the second limitation, I also scheduled and carried out "multiple observations over time" (Creswell, 2015b, p. 214) – a minimum of 2 and maximum of 5, 60-minute classroom observations of teaching per teacher.

When feasible, I conducted classroom observations at a time that allowed for immediate, follow-up, one-on-one debriefing between the teacher and myself (observing classes before lunch or non-contact periods) to discuss my findings and clarify potential misperceptions (Stringer, 2014). My ability to debrief was also greatly enhanced by the teachers' decisions to conduct *Reconnaissance* only after the senior students left for study leave; this meant that many teachers had 2-3 non-contact periods available per day during data collection. Combining classroom observing with teacher debriefing allowed me to gain greater understanding of teachers' aims and lesson purposes within the wider unit context.

Observations were guided by, but not limited to, an observation template (Appendix M). The template was developed from the quantitative survey content as well as Kanevsky's (2011a, 2013) work in deferential differentiation. The observation template was photocopied onto three single-sided A3 sheets to allow plenty of room for annotation. For each differentiated strategy listed on the online survey there were three observation template columns for me to check, ‘Observed’, ‘Not Observed’, or ‘Not Applicable’ as not every strategy could be incorporated into individual 60-minute science lessons. I found it helpful to use two different colour pens to indicate additional information gained in the debriefing or post-observations interview sessions, which at times, resulted in annotations and modifications of observations recorded (i.e., teaching explanation of the selection of the lesson topic due to student feedback, proficiency or difficulty).

When conducting observations with the observation templates, I took great care to give an in-depth and detailed but uncluttered, accurate, factual account of the setting. This entailed describing what I observed, which activities took place, and who participated to clarify the context as suggested by Patton (2015) as the “first-order purpose of observation data” (p. 332). I followed the advice of A. P. Johnson (2008) to “stop thinking and just write what you see” (p. 83). Whenever feasible, I attached teachers’ lesson plans and supporting student documents.

All lesson observations and supporting documents were scanned digitally and/organised by teacher and year group for qualitative analysis. They were used to clarify and extend quantitative findings: (a) differentiation valued and used in existing science classrooms (*high* value and usage), (b) differentiation least valued and used in existing science classrooms (*low* value and usage) and (c) differentiation considered important but seldom used in existing science classrooms (*high* value and *low* usage).

In addition, lesson observations provided me with first-hand classroom experience from which to adjust my interview question schedule to make it more relevant to current classroom practice. This included asking teachers how they assessed and incorporated student prior knowledge and ability, planned for and challenged talented science students or supported students with learning difficulties, such as dyslexia or dysgraphia. It also involved asking students to provide specific characteristics or attributes of the school’s science teachers and classroom environments that encouraged or inhibited student ability to learn science.

As a practitioner-researcher, I was well aware that two to five classroom observations only provided a small glimpse of what occurred in participants’ science classrooms on a daily basis throughout the school year (Mertler, 2014). Classroom observations did not necessarily reveal the lesson context or purpose within a teacher’s unit scheme, year plan or the school’s secondary science curriculum. Similarly, the decisions behind lesson content, process, product selection or altering instruction in response to observed student knowledge, questions or behaviour in the classroom were not always clear to me as a classroom observer. Because of this, I relied on qualitative interviewing post-classroom observations to assist me in gathering more details to better understand the big picture (Creswell, 2015a; D. L. Morgan, 2014a) of how differentiation was evidenced and understood by teachers, students and whānau.

Qualitative interviews. A research interview is defined by DeMarrais and Lapan (2004) as a "process in which a researcher and participant engage in a conversation focused on questions related to a research study" (p. 55). Dexter (1970) describes such an interview as a "conversation with a purpose" (p. 136) as cited by Merriam and Tisdell (2016, p. 108). Typically, that purpose is to enter into another person's perspective, discovering what is "in and on someone else's mind" (Patton, 2015, p. 426). Patton explains,

> We interview people to find out from them those things we cannot directly observe . . . feelings, thoughts and intentions . . . We cannot observe situations that preclude the presence of an observer . . . [or] how people have organised the world and the meanings they attach to what goes on in the world. We have to ask people questions about those things.

While some justify their use of interviews to "get better data or more data or data at less cost than other tactics" (Dexter, 1970, p. 11), Merriam and Tisdell (2016) point out that "depending on the topic, interviewing is sometimes the only way to get data" (p. 109).

Interviews tend to be "person-to-person encounter[s] in which one person elicits information from another" (Merriam & Tisdell, 2016, p. 108). Although one-on-one is the most common interview research format, collective interview formats are also widely used (Merriam & Tisdell, 2016). Qualitative interviewers assume that the perspectives of others are "meaningful and knowable and can be made explicit" (Patton, 2015, p. 426).

Research interview conversations have "a structure and a purpose . . . [unlike] the spontaneous exchange of views in everyday conversation" (Brinkmann & Kvale, 2015, p. 5). Interview formats range from highly structured questionnaires to open-ended conversations (Merriam & Tisdell, 2016). As a constructivist, I chose to implement a semi-structured interview format because it enabled individuals to share differing perspectives on how they viewed the world (Merriam & Tisdell, 2016). Semi-structured interviews are characterised by Merriam and Tisdell (2016) as having:

- an interview guide composed of a mixture of more and less structured questions,
- flexible use of all questions,
- some specific data sought from all participants,
- the bulk of the interview guided "by list of questions or issues to be explored," [and]
- no predetermined wording or order" (p. 110).

The quality and wording of interview questions greatly impacts the legitimacy of the data collected (Creswell, 2015a; Merriam & Tisdell, 2016; Patton, 2015); "the way and questions are worded is a crucial consideration in extracting the type of information desired" (Merriam & Tisdell, 2016, p. 117). To minimise researcher bias, qualitative interview questions, such as those employed in this MMAR study should be written in a way that allows each interview participant to voice their perspective unconstrained by the input of the researcher or study findings (Creswell, 2015b; Mertler, 2014; Patton, 2015).

The pre-determined, clearly worded, closed and open-ended questions of my interview guides were designed to elicit in-depth, thoughtful participant responses to help me achieve my purpose of determining how differentiated teaching and learning was understood from the perspectives of years 9 and 10 science teachers, students and whānau (Creswell, 2015b; Merriam & Tisdell, 2016; Mertler, 2014; Patton, 2015). All interview guide questions were submitted to supervisors prior to the interviews and revised accordingly to promote bicultural engagement of diverse teachers, students and whānau in alignment with the principles of the *Te Tiriti o Waitangi*. I am aware, however, that I, like all qualitative interviewers, may have unknowingly prejudiced participant responses in my verbal or non-verbal communication through tone of voice and body gestures (Creswell, 2015a).

The format and wording of my teacher, student and whānau mixed structure interview guides stemmed from Kiley's (2011) *Teacher Self-Reflection of Differentiation of Instruction Questionnaire*. All questions were selected to gain a deeper understanding of (a) the influences and factors related to teachers' differentiation of the science curriculum and (b) how teachers, students and whānau perceived existing science differentiated teaching and learning practices. A semi-structured interview approach allowed me to ask base questions with the flexibility of alternative, spontaneous follow-up questions in response to participants' answers (Merriam & Tisdell, 2016; Mertler, 2014). To minimise bias through administration mode, I was the only interviewer who conducted interviews (Creswell, 2015a). I followed the dialogue of interviewees, conscious of and adhering to our pre-agreed time-frame [L. T. Smith's (1999) manaaki ki te tangata]. This enabled a more natural and egalitarian relationship between the interviewees and me (Brinkmann & Kvale, 2015; Kvale, 1996; Skinner, 2012).

Although qualitative interviews seek to understand a person's experience or perspective of a situation rather than influence, give interpretations or advice (Patton, 2015), critics argue that a threat to legitimacy in qualitative interviewing is obtaining "reactions to the investigator's preconceived notions of the world" (Merriam & Tisdell, 2016). In asking participants questions in person [L. T. Smith's (1999) he kanohi kitea] and not rigidly adhering to pre-determined questions

(Merriam & Tisdell, 2016), I addressed this threat, accessing participants' diverse perspectives and understandings of the differentiated science teaching and learning. My use of audio recording, computer transcription and analysis software also increased the potential for both the efficiency and accuracy with which participant perspective was captured in interviews (Creswell, 2015b).

Well-conducted individual and collective qualitative interviews provide researchers with an effective mixed methods tool to extend their understanding of participant perspectives gathered on other quantitative and/or qualitative data (D. L. Morgan, 2014a). I utilised qualitative interviews in the *Reconnaissance* and *Evaluating* phases of my research to extend my understanding of the quantitative online survey responses, as well as the qualitative classroom observations. I incorporated both individual and collective interviews in this study. My rationale for using both individual and collective interviews as well as the interview instrument design, data collection process, and advantages and disadvantages of one-on-one and focus group interviews is now explained.

Teacher individual interviews. Teachers had the opportunity to expand upon their qualitative classroom observations and online quantitative survey responses (if completed prior to the interview) during individual interviews with me. I selected one-on-one interviewing because, although individual interviews are time-consuming, they have been proven useful for asking personal, sensitive questions of participants (Brinkmann & Kvale, 2015; Creswell, 2015a; Merriam & Tisdell, 2016). Individual interviews were suitable because the teachers were more likely to be comfortable expressing their perspectives on differentiated science teaching learning one-on-one and the aim was to understand individual teachers' views in-depth (Merriam & Tisdell, 2016; Norman, 2016).

My teacher interviews afforded all teachers the opportunity to have a voice. They also give interviewees the opportunity to ask the interviewer questions and/or provide comments that go beyond the interview guide's base questions (Brinkmann & Kvale, 2015; Creswell, 2015a). However, I acknowledge that my on-going collegial relationship with teacher participants, and the lack of anonymity in a one-on-one setting, may have kept some teachers from disclosing information during the interview (Creswell, 2015a). To encourage full participation of all teachers, I scheduled the interviews in advance (Creswell, 2015a) and, in accordance with aroha ki te tangata (Cram, 2001; L. T. Smith, 1999), at a time and venue that was selected by participants. In alignment with Te Tiriti's principles of partnership, participation and protection for educational research, I altered interview dates or times in response to unexpected classroom, extra-curricular or whānau commitments (Cram, 2001; Ministry for Culture and Heritage, 2016; L. T. Smith, 1999).

I followed Patton's (2015) utilisation-focused evaluation interview design that is typically done "with people in organisations and communities… seek[ing] solutions to problems [through] short, focused interviews lasting an hour or less" (p. 436). My interviews exhibited an "intense reliance on personalised seeing, hearing, [and] experiencing in specific social settings" (Van Maanen, 2011, p. 156) such as in the secondary classroom from the perspective of a science teacher. In addition to the interview guide questions described earlier in this chapter (see Appendix N), I probed teachers' interpretations, values, knowledge and experiences with differentiation. I also explored barriers to differentiation, such as timetabling, planning and management support to gain a fuller understanding of teachers' perspectives (Merriam & Tisdell, 2016; Patton, 2015).

Teacher responses to the individual interviews were chronicled in my field notes and, when granted consent by participating teachers, audio recorded to allow for transcription. As previously explained in my research design chapter, all teacher interviews directly followed my classroom observations whenever possible. This adhered to Stringer's (2014) policy of "participant debriefing" (p. 93) as I sought to incorporate feelings and responses of participants. Key themes that emerged from the one-on-one teacher interviews and supporting teacher responses are discussed in the findings section of this chapter.

Group interviews: Focus groups. In the most simplistic sense, a focus group is defined as a small group interview in which four to six participants engage in collective discussion facilitated by a moderator (Kamberelis & Dimitriadis, 2011). Focus group participants are typically selected for their connection to a particular research topic (Creswell, 2015b; Krueger & Casey, 2015). My role as a focus group moderator was not to gain consensus from participants regarding the research topic, but rather to create a non-judgemental atmosphere that allowed for participants' open expression of personal and possibly conflicting viewpoints (Brinkmann & Kvale, 2015).

Focus groups interviews have been proven to be an effective research mode of collecting reliable qualitative data in education, particularly for obtaining perceptions and/or beliefs (Creswell, 2015a; Hubbard & Power, 2003; Krueger & Casey, 2015; Vaughn, Schumm, & Sinagub, 1996). They exist at a junction of "pedagogy, activism, and interpretive inquiry" (Kamberelis & Dimitriadis, 2011, p. 545). I chose to incorporate focus group interview research into my MMAR due to its ability "to conduct an interactive discussion that can elicit a greater, more in-depth understanding of perceptions, beliefs, attitudes, and experiences from multiple points of view and to document the context from which those understandings were derived" (Vaughn et al., 1996, p. 16).

Focus groups offered a personal approach to data collection, allowing me the opportunity to directly interact with key individuals, yielding greater insight into stakeholders' thoughts and feelings. Although a focus group moderator should be guided by well-prepared research questions and interview schedules, evolving discussions often reveal unanticipated yet pertinent issues and concerns (Vaughn et al., 1996). The group context provided me with an opportunity to practise L. T. Smith's (2005) 'community-up' culturally responsive concepts of titiro, whakarongo . . . kōrero and he kanohi kitea as I directly observed, looked and listened to individual and collective stakeholder experiences regarding differentiated teaching and learning.

Some of the advantages that focus groups hold over other forms of qualitative data collection include:

- synergism, as a more extensive data bank often emerges from dynamic group interaction among participants;
- snowballing, as statements from one respondent prompt a chain reaction of related comments from others;
- stimulation, as participants gain excitement from the enthusiasm of other respondents;
- security, when group members are comfortable with each other, thus promoting a 'loosening effect' and candid discussion and
- spontaneity, as individual participants feel less one-on-one pressure to answer every question, responses shared become more open, frank, honest and spontaneous (Hess, 1968; Vaughn et al., 1996).

However, as with any research strategy, there are potential limitations to deriving data from focus groups. Two key reasons that focus groups, or other "group experiences turn into wasted time are: unclear purpose or inappropriate processes" (Krueger & Casey, 2015, p. 1). Therefore, it is not surprising that a key criticism of focus group interviewing as a research technique is a lack of preparation by the moderator and insufficient questions (Vaughn et al., 1996). Creswell (2015a) also cautions that if some individuals dominate the focus group conversation, data gained will not reflect the consensus of the group. To counter these criticisms, the interview guides in my study were:

- organised well in advance of the focus groups (see prepared interview guides in Appendices O-P);
- designed from effective evidence-based focus group questioning and moderation

strategies, including pause and probe techniques and preparing for the unexpected (Krueger & Casey, 2015) and

- critiqued, modified, and approved via multiple research and/or educational experts including research supervisors, the Massey University Human Ethics Committee and international/local teachers.

A thorough review of literature in the field of focus groups and professional science education background also assisted me in providing a platform from which to combat moderation issues such as dominant talkers, shy participants and ramblers using non-verbal communication, humour and a variety of verbal responses (Krueger & Casey, 2015). Even so, I still experienced what Brinkmann and Kvale (2015) identify as a common cost of lively focus groups, "interview transcripts that are somewhat chaotic" (p. 176), as enthusiastic participants often interrupted and talked over each other. Therefore, an irrefutable limitation of my focus group data collection is that some of this dialogue was indecipherable for transcription and was excluded from data analysis. Furthermore, the lack of anonymity in a focus group setting may have kept some students and whānau from disclosing information during the interview (Creswell, 2015a).

Another criticism of focus groups is the lack of overall generalisability of information elicited, for all interview information gathered must be treated as a specific collection of viewpoints from a selected group of individuals and not the perspectives of the school, village or community as a whole (Vaughn et al., 1996). However, as viable components of a school's community, views of years 9 and 10 science teachers, students and whānau are still valid and worth reflecting upon. Kamberelis and Dimitriadis (2011) argue that this is actually an aspect of the multi-functionality of focus groups, which like a prism, can only be seen directly from one surface at a time but with multiple layers that reflect light.

A further area of potential error in analysing focus group responses is the misinterpretation of data (Krueger & Casey, 2015; Vaughn et al., 1996). I addressed this limitation by first conducting multiple focus groups both within (n = 4 student focus groups) and among different stakeholders (students separate from whānau). I utilised both field notes (Hubbard & Power, 2003) and audio recordings to chronicle focus group discussions. I sent focus group audio recordings to unbiased Massey-recommended audio transcribers. Upon discovering multiple errors in the finished transcripts, I drew on my experience with science classroom pedagogy terminology and familiarity with stakeholders' unique cultural and generational dialect, slang and vocabulary to personally re-transcribe all transcripts.

To increase analysis accuracy, I selected a combination of editing tools including Express Scribe, Google audio documents and NVivo 11.4.0 for Mac qualitative data analysis computer software. The qualitative analysis section later in this chapter explains my process of coding the edited transcriptions in NVivo and conducting thematic analysis to aid in my understanding of how focus group participants understood differentiation of the science curriculum. Preceding the analysis, however, are the next two subsections, which provide insight into my conduct of *Reconnaissance* students and whānau focus groups, including the precautions I took to address potential limitations specific to each group of participants.

Student focus groups. All students who partook in the online surveys were invited to participate in focus groups to enable me to better understand quantitative survey results. Interest in focus group participation was high (69% of survey respondents participated in focus groups; n = 27) resulting in 4 consecutive lunchtime focus groups that represented the school's diverse student population (gender, ethnicity, demographics, interest in or capability in science and year group). I incorporated Krueger and Casey's (2015) recommended strategies for facilitating focus group interviewing with young people, including: (a) selecting a mixed group, (b) asking age appropriate questions, (c) keeping the age range within two years, (d) being aware of age-related behaviours, (e) shortening the time of the group and (f) finding a friendly location were all employed. The student focus group hui were held pre- and post-implementation of the differentiated teaching and learning collaborative unit during the *Reconnaissance* and *Evaluating* phases and audio-recorded with these students in various school meeting rooms at lunchtime. I used comments and discussions made by students to add complexity and depth to responses on the student quantitative surveys and my classroom observations.

I approached the focus groups with specific closed and open-ended questions exploring student and whānau perceptions of teachers' awareness of students' learning needs and use of science teaching and learning strategies for differentiating content, process and product (see Appendices O & P). Sample student and whānau questions are highlighted in Table 6.1.

Table 6.1: Sample Student and Whānau Focus Group Questions Probing Teachers' Differentiated Teaching and Student Learning

Students	What do your science teachers do that you find helpful for learning in the class? What do you wish your science teachers would do to help you learn better? Educators use the term *differentiation* to talk about what they do to help each unique student succeed. If you were a teacher, how would you differentiate in your science class?	Whānau	Do science teachers incorporate your child's interests into teaching and learning? If so, how? Do science teachers know your child's strengths and weaknesses and factor this into teaching and learning? Please explain.

I also remained open to and documented topics that emerged from focus group discussions that, although holding no direct connection to any interview question, were still applicable to science differentiated teaching and learning. For example, student conversation on how current teachers addressed the needs of science students with learning difficulties diverged from my intended direction into a discussion of effective strategies employed by students' previous primary school teachers. The divergence provided my participating research teachers with practical ideas and insights for consideration when accommodating the needs of students with dyslexia or dysgraphia in the *Planning* phase. Such divergent yet relevant, meaningful conversations are a phenomenon highlighted by Vaughn et al. (1996) as a strength of well-conducted focus groups.

Whānau focus groups. All whānau of years 9 and 10 students at the college were invited to be part of the whānau focus groups. As part of the whānau consent form for student research participation, whānau provided an expression of interest or disinterest in participating in whānau focus groups. Eight whānau members expressed an interest (all but one had children who participated in the study). After conducting classroom observations, I contacted an additional 2 whānau with whom I had previously established relationships and I felt would bring different perspectives to the study (particularly from the year 10 learning difficulties and scientifically talented viewpoints). Preferred times and venues for meeting had been indicated on the expression of interest form. I followed up by contacting interested participants directly to finalise the best overall group interview time and location.

Based on whānau input regarding work and family commitments, I chose to conduct the 1-hr long whānau focus group hui in the school leadership meeting room at 2 pm in the afternoon. This aligned the hui ending time with school dismissal, enabling parents to transport children home without an extra trip to school [aroha ki te tangata (Cram, 2001; L. T. Smith, 1999)]. This also provided the opportunity for whānau who wanted to ask follow-up questions or contribute additional personal information to stay longer and communicate with me one-on-one [titiro, whakarongo, kōrero (Cram, 2001; L. T. Smith, 1999)]. Unfortunately, the afternoon timeslot meant that one interested participant was unable to attend; however, whānau indicated that alternative time slots would have resulted in fewer participating whānau. As with student focus group interviews, the whānau focus group hui were held pre- and post-implementation of the differentiated teaching and learning collaborative unit during the *Reconnaissance* and *Evaluating* phases. The qualitative thematic analysis of data collected in *Reconnaissance* and

Evaluating focus group interviews, as well as individual teachers' interview responses and observations of science teachers' interaction with students, is explained in the following section of this chapter.

Qualitative Thematic Analysis

Qualitative analysis requires making sense of images and text to answer research questions (Creswell, 2015a). I selected constant comparative analysis (Leech & Onwuegbuzie, 2007) as the framework from which to undertake the challenge of integrating and making meaning of the large amount of collected written, spoken and visual data (Patton, 2015). Constant comparison, or coding analysis, has been identified as a particularly useful strategy when analysing an entire dataset for underlying themes, values and perspectives (Leech & Onwuegbuzie, 2007). I chose to conduct my constant comparison analysis inductively, allowing codes to emerge from my data, rather than pre-identifying codes prior to analysis (Leech & Onwuegbuzie, 2007).

As is characteristic of constant comparison analysis, I first read through all collected sources to gain a big picture perspective of my data (Leech & Onwuegbuzie, 2007). Utilising NVivo I then divided the dataset into meaningful data chunks, labelling each section by a descriptive title also known as a code (or node in NVivo). I compared each new data segment to previous chunks to ensure like chunks were labelled with the same codes. I uploaded transcripts into NVivo so that each participant's responses appeared under a unique case code by stakeholder type (teacher, student, whānau), ethnicity and year group (9 or 10). Relevance was determined by:

- recurrence of topic,
- emphasis of topic within or between stakeholder groups or
- connection/contradiction to quantitative findings or existing research in differentiated teaching and learning.

Although I transcribed and included my interview questions and interviewer discourse in the NVivo transcripts for contextual reference, I excluded my speech from the coding process to direct the focus of analysis on participant rather than interviewer input.

The initial qualitative data coding resulted in 96 key concepts of differentiated content (30), process (37), product (13) and classroom environment (16), including some that interrelated or overlapped. I next grouped the 96 key concepts based on similarities, which led to 25 themes. I endeavoured to make all 25 themes mutually exclusive, but again, some interrelationship and overlapping was unavoidable. Those themes that appeared most often or supported and/or contradicted quantitative findings were brought back to stakeholders to assess their appropriateness, relevance and meaningfulness to differentiated teaching and learning in subsequent research phases (Charmaz, 2000; Leech & Onwuegbuzie, 2007) and used as the basis for collaborative decisions and actions in *Planning, Acting* and *Evaluating* phases. The *Reconnaissance* qualitative themes and their implications for subsequent MMAR phases are discussed within the ensuing results section of this chapter.

Qualitative Findings

The following results are synthesised from the open-ended responses on the teacher and student online differentiated teaching and learning surveys (introduced in Chapter 5), teacher classroom observations, individual teacher interviews and student or whānau focus group interviews. The qualitative research results are first divided into subsections largely based on emerging themes that arose from teacher individual interviews and student and whānau focus group interviews. Within these groupings, thematic categories are introduced based on their (a) recurrence, (b) emphasis and (c) connection and/or contradiction to quantitative findings or existing differentiated teaching and learning literature (as explained earlier in this chapter).

The findings from teacher individual interviews and classroom observations primarily stemmed from teachers' perceptions of:

- what differentiation was,
- personal competence and confidence in facilitating differentiated learning for years 9 and 10 science students,
- how individual teachers differentiated in current years 9 and 10 teaching practice and
- barriers to effective differentiation in years 9 and 10 science classrooms.

Themes emerging from student and whānau focus group discussions have been divided into three overall categories: instructional environment, physical environment and psychosocial environment. Given the Māori bicultural context of the research setting, psychosocial factors are referred to as manaakitanga (respect, generosity and care for others) in corresponding text and supporting tables. Within this chapter, I also acknowledge those themes that most supported or contradicted quantitative survey findings previously described in Chapter 5 or connections to existing science differentiated teaching and learning literature introduced in Chapter 2 including:

- assessment and accommodation of student readiness;
- variety in science teaching and learning;
- relevance of science teaching and learning;
- effective, pro-active communication between teachers and students/whānau' and
- teacher-student relationship and the concept of whakamā (the feeling of being ashamed, shy, bashful, embarrassed).

Direct supporting evidence from stakeholders is incorporated and explained throughout this chapter.

Teachers' perceptions of differentiated teaching and learning. Participating science teachers held differing perceptions of what differentiation was and how they incorporated it in their years 9 and 10 classrooms, as shown in Table 6.2 and explained in the following subsections of this chapter. While three of the teachers felt confident and competent to deliver differentiation, Sage saw herself as a somewhat confident, advanced beginner.

The findings shared in this chapter are integrated from teachers' *Reconnaissance* interview and survey responses asking them to explain what differentiation was and how they, as individual teachers, implemented differentiated teaching and learning in current years 9 and 10 science classroom practice. Self-ranking of differentiation knowledge and competence were included as a reference to monitor changes as the MMAR study developed. Although Turin did not partake in the *Reconnaissance* online differentiated science teaching survey in 2015, I chose to include his *Evaluating* survey responses (May, 2016) to represent the contributions and approach to differentiation that he brought to the *Planning* and *Acting* phases, as they reflected the views Turin expressed regarding differentiation in my introductory individual interview with him at the start of the 2016 school year (February, 2016).

Differentiation defined. The second column in Table 6.2 shows teachers' verbatim written responses to the open-ended responses to the teacher survey's query, 'How would you define differentiated instruction?' All four participating teachers' definitions emphasised the importance of "challenging learning experiences" (Alton) that "allow students to work at a level appropriate for the individual" (Turin). Sage was the only teacher who specifically identified the need to address the learners at upper and lower ends of the learning spectrum in her definition with, "harder work for those more able (and more work)" and "simpler work that still covers the basics for those who struggle."

Alton, Casper and Turin all referenced "individual" students as a determining factor in classroom differentiation. However, teachers also questioned the feasibility of providing differentiation that catered for every student's individual needs each day. Turin admitted, "I don't believe in full differentiation as defined by everyone doing their own thing; difficult to manage without proper training and extremely motivated kids" (individual interview).

Table 6.2: Teachers' *Reconnaissance* Perspectives on the Definition and Implementation of Differentiation in Existing Science Classroom Teaching and Learning

Teacher	Differentiation defined	Self-ranking: Differentiation competence	Self-ranking: Differentiation confidence	Current differentiation for years 9 and 10 students
Alton	Providing learning experiences for individuals in the class which provides challenging learning experiences at each student's ability level	Competent	Confident	• Aim work at mid upper end of the class and differentiate through teacher pupil interactions • Promote access for lower ability through teacher intervention • Question upper ability to extend learning beyond the main learning objectives • Some differentiation through task and resources
Sage	Giving work suitable to the student, for example, harder work for those more able (and more work), easier more simpler work that still covers the basics for those who struggle	Advanced beginner	Somewhat confident	• Extra work for those who finish early • Minimum requirements for those who struggle that I help them with
Casper	Providing different, fit for diverse learners, contents, strategies that brings the best in the individual learner	Competent	Confident	• Grouping of mixed-ability • Provide leadership and extra content, worksheets • Give research-based topics to suit the diverse tastes of the learners
Turin	Stimulating, learning activities that allow students to work at a level appropriate for the individual	Competent	Confident	• I don't believe in full differentiation as defined by everyone doing their own thing; difficult to manage without proper training and extremely motivated kids • Assess understanding by constant movement around room and dialogue with students • Thinking of providing bright Year 9 Māori male with work that he can do at home to challenge himself without letting his mates know he is doing it

Current practice. Although all teachers reported differentiating for current years 9 and 10 students, qualitative data collected through online survey responses, classroom observations and individual interviews indicated variety in what and how teachers implemented differentiation (see Table 6.2). I grouped the differentiated strategies described by teachers into two broad categories based on their similarities and differences, (a) on-going assessment and responsivity to student readiness and (b) methods for catering for students at the ends of the learning continuum – high-achieving and low-achieving leaners.

Assessment and accommodation of student readiness. Both Turin and Casper reported the science department's twice yearly (February and December of years 7-10) use of the New Zealand Council for Educational Research's (NZCER) 'Thinking with Evidence' standardised test as helpful in assisting them as new teachers in establishing students' ability. However, Turin cautioned that such tests should only be a guide. He observed "a year 7 boy scored off the charts but when you talk to him he cannot communicate well at all, so tests can be a starting place but observations, interactions, etc. are also helpful" (individual interview). Casper noted that individual students might both excel and struggle in science knowledge, skill acquisition or application. Casper had detected some current learners "do better in practical oriented lessons while the same student struggles with worksheet, application questions" (open-ended survey response).

Sage commented on her evolving approach to science teaching units, lesson planning and implementation over the past 7 years in response to observed student needs. She reflected, "I used to plan by term in detail, but … [now] go by what the kids actually do, learn and need to know" elaborating that she currently "use[s] lesson unit plans and make modifications to meet year group [needs] and fit my strengths" (individual interview).

Both Alton and Turin emphasised in their open-ended survey responses the importance of maintaining teacher awareness of students' current unit knowledge and ability through daily, dynamic "teacher pupil interactions" (Alton). Turin explained how he, especially as a new teacher to the school, continually assessed "understanding by constant movement around the room and dialogue with students." Certainly, classroom observations confirmed that both Alton and Turin were the teacher participants who most frequently engaged in movement around the room, initiating interactions with students that both extended and/or supported individual thinking when applicable, especially during non-lecture-oriented activities such as microscope investigations (Turin) or voltage experiments (Alton). I observed Alton promoting metacognitive self-evaluation skills among year 10 students who were seeking his approval. Instead of providing instant teacher feedback he asked them, "You tell me," encouraging them to practise scientific discourse as they analysed their current circuit design, describing both strengths and weaknesses. Additional specific examples of Turin and Alton's learning interactions with students are integrated into student and teacher focus group perspectives on communication later in this chapter.

Alton also reported in his *Reconnaissance* open-ended survey response that he incorporated “some [additional content, process or product] differentiation through task and resources” in response to student need but did not provide specific examples. Casper identified the use of “research-based topics to suit the diverse tastes of the learners” (*Reconnaissance* open-ended survey response) as a strategy he used to respond to learners’ interests and incorporate process differentiation. *Reconnaissance* classroom observations of Sage revealed evidence of year 10 students conducting such individual research projects in the area of genetics for their human reproduction unit.

Accommodation for low- and high-ability students. Although participating teachers were not specifically asked to explain how they differentiated to meet the needs of students identified as ‘at-risk’ within science education, such as students with learning difficulties, talented science students and students of non-dominant cultures, several teachers did provide examples for these groups in their *Reconnaissance* open-ended survey responses. Alton identified it helpful to set content “work that is aimed at the mid upper end of the class” and then promote “access to the work through teacher interventions with the lower ability.” Sage reported scaffolding for students with difficulties by establishing “minimum requirements” for “those who struggle… that I help them with that is less than what I expect from the other students.” Casper stated that “grouping of mixed-ability often provides the first port of call before I intervene or extend” implying students of lower abilities achieve better when guided by the “leadership” of more able pupils. Casper also reflected in his *Reconnaissance* individual interview that there was a need “to adjust [lower] my units for levels of understanding” to match student ability in his transition to teaching junior science classes for the first time in 2015.

Turin did not provide any specific examples of meeting the needs of students with learning difficulties in the teacher open-ended survey response. However, I observed (February 2016) both group and individual scaffolding in Turin’s facilitation of a microscope investigation into onion cells with learners who struggled with low-literacy skills (February, 2016). Examples of scaffolding included:

- simplified verbal directions supported by a typed written hand-out with illustrations for students to reference during the ‘practical’;
- teacher demonstration of the skills required to prepare and view the microscope onion specimen, “So, your onion goes like this, and that little bit of glass it goes on top . . . Remember? With the slide on the microscope . . . you start on the low-powered first, the small lens, and slowly work your way up” and
- on-going clarification as Turin moved throughout the room, interacting with working

students, "Hey, shush! Pay attention. It's too wet. You need to wipe everything before you put it on!" Turin expressed interest when students initiated interactions with him, sharing their findings, "Sir, have a look at that one, it looks like a mussel that you eat!"

At the other end of the learning spectrum, Alton identified the importance of strategic one-on-one questioning as a critical tool for process differentiation to stimulate "the upper ability students to extend their learning beyond the main learning objective" (open-ended survey response). Sage and Casper reported that when they did provide high-ability students with differentiated content it tended to be through additional work "usually have extra for those who finish early" (Sage, open-ended survey response) in the form of "worksheets at different stages of the topic" (Casper, open-ended survey response). This action was confirmed in observations of years 9 and 10 classrooms and/or student work of both teachers during topics such as photosynthesis, forces and reproduction. In brainstorming how to challenge a year 9 Māori male that Turin observed had abilities far above his peers in a low-literacy class, Turin identified the importance of recognising and responding to the Māori cultural value of māhaki (humility), proposing, "work that he can do at home to challenge himself without letting his mates know he is doing it 'cause he will be quite bored at the pace everyone else is working."

Requested professional learning and support. Although three of four participating teachers rated themselves as competent and confident in differentiating science teaching and learning during individual interviews, all four teachers openly expressed a need for on-going personal development and growth in their knowledge of and approach to differentiated teaching and learning. Specific areas identified by individual teachers for professional learning in differentiated teaching are highlighted in Table 6.3. Teacher-selected topics represented the breadth of curriculum differentiation from pre-assessment of prior knowledge to product evaluation. Also highlighted in the table are teachers' perceptions of the barriers that kept them from differentiating more, including their teaching responsibilities, as all participants cited teacher workload as the primary challenge to differentiating science curriculum.

Table 6.3: Teacher Identified Differentiation Barriers and Support Requested in Response to Teaching Responsibilities

Teacher	Teaching responsibilities	Planning time	Differentiation barriers	Differentiation professional support requested
Alton	• Junior Integrated Science • Senior Chemistry • Senior Physics* • Head of Faculty • *Kia Eke Panuku* Advisor • Co-coordinator for school-wide Education Outside the Classroom	• Spend 2-3 hours a day on average outside of school designated preparation time	• Time • Workload	• Would like to reinforce or correct what I think I know about differentiation with current up-to-date examples, especially interactive process approaches • Product is a weakness as it's the first thing to get minimised if I'm running out of time – end up relying on formative assessment gathered prior to end of unit • Would be good to spend time on outcome as quite often outcomes/product is the area that gets neglected.
Sage	• Junior Integrated Science* • Junior Agriculture Science* • Junior Integrated Science • Senior Agriculture Science (low-literacy) • Video-Conference Senior Agriculture Science (high-achieving)* • Sports Coach	• Always working at interval (20 minutes) and lunch (1 hr) • 1/2 hour to 1 hour at home nightly. • Good couple hours on weekend	• Time • Workload – complete chaos • Limited resources – money for materials • Restrictive classroom structure – room is a pain with insufficient lab work stations and data projected on whiteboard	• None
Casper	• Junior Integrated Science* • Senior Physics	• Minimum 4 hours of planning per day at home	• Limited resources - getting management to resource money and materials (workbooks/ textbooks) • Restrictive classroom structure – prefer wall-less, team-teaching approach • Competing professional development from outside initiatives • New school environment • Teaching outside area of expertise – junior instead of senior science	• Extension work, provide new knowledge • Equally difficult to support differentiation for low and high kids
Turin	In 2016: • Senior Biology • Senior Integrated Science • Junior Integrated Science • Sports Coach	• Tend to plan 2 hours per day outside 1-hour non-contact	• Limited resources – tiny labs, lack of technician • Communication • New school environment	• Mostly I would like learning objectives so that I know where we are headed - that helps me plan more • No pre-test for the first unit, would like to make sure there is some type of probing of prior knowledge to help with responsive teaching

* New subject area/or year group for teacher previously untaught before

Casper was the only teacher to target his professional development in the area of meeting the needs of students at the extremes of the learning continuum, identifying a need to grow in capacity to “support differentiation for low and high kids” particularly through offering “extension work” and “provid[ing] new knowledge” to scientifically talented junior students. Sage did not cite any specific target for differentiated professional learning and development in the *Reconnaissance* phase, but later chose to focus on developing her ability to pre-assess student knowledge during the *Planning* and *Acting* phases, which will be further discussed in Chapter 7.

Having had little differentiated teaching and learning since teacher-training, and none in the past five years, Alton was quite keen to learn more about current developments in differentiation to “reinforce or correct what I think I know about differentiation with current up-to-date examples, especially interactive approaches” (individual interview). Alton also noted that he would like to focus on differentiation of product for he felt “product [to be] a weakness as it’s the first thing to get minimised if I’m running out of time – end up relying on formative assessment gathered prior to end of unit” (individual interview).

Alton also described in the *Reconnaissance* interview a need within the department to “spend time on outcome as quite often outcomes/product is the area that gets neglected.” Although new to the department in 2016, Turin voiced similar concerns regarding outcome when seeking to determine which learning objectives to promote in his junior science classes in Term 1, stating the most practical differentiated assistance he could have is “Learning objectives so that I know where we are headed. That helps me more.” Turin noted the absence of a “pre-test for the first unit” citing “some type of probing of prior knowledge [would] help with responsive teaching” (individual interview).

Barriers to differentiation. When considering current classroom differentiation practices and the potential to grow professionally in their ability to differentiate curriculum responsive to the needs of years 9 and 10 science students and whānau, all four participating teachers identified barriers to differentiation (Table 6.3) that corresponded to issues such as teacher workload, limited resources, inadequate laboratory facilities or classroom supplies and competing professional development initiatives. I classified *Reconnaissance* teacher identified barriers, as well as those identified by Turin at the beginning of his employment in 2016, into two major categories, teacher workload and classroom resources; the latter of which is further divided into physical and organisational environment challenges.

Teacher workload. Indeed, “time” pressures were the most frequent challenge to differentiation cited in teachers’ open-ended survey responses and individual interviews. Time appeared to limit teachers’ differentiation ability regardless of their years of experience at the school (0-7 years) or in the teaching profession (7-34 years). Sage reflected common teacher sentiments,

> Time is very precious and teachers seem to be pushed for time always. What we would like to be doing and teaching our students can be different to what actually is taught and how, due to lack of time for preparation (survey).

Table 6.3 details teachers’ workload in the form of classroom, school leadership and extracurricular teaching responsibilities during the *Reconnaissance* data collection phase in 2015, as well as Turin’s teaching load at the start of the 2016 school year. The asterisks indicate subjects or year levels previously not taught by that teacher, requiring additional preparation. Teachers reported spending an average of between 2 and 4+ hours a day on preparing for their science classes outside of their designated 1-hour non-contact period. Casper described his typical time spent preparing at home as,

> I do a lot of searching for resources to use in class, mostly online. I also spend time typing up and/or modifying activities and lessons, designing group activities such as cut and match for year 10 lesson[s], starter activities, questionnaires for students, working on alternative thinking (individual interview).

Teachers taught a minimum of four different science classes across multiple levels. Although experienced science teachers, both Casper and Turin identified teaching in a new school resulted in extra time and preparation as they adjusted to new leadership, students and curriculum objectives. Turin observed, “Not sure if I’m the only one not knowing because I’m new or if we are all clueless” (individual interview). Alton found his biggest time challenge to be mentoring and managing new staff. Sage’s teaching course workload was the heaviest, with up to 9 different courses in a week. She summarised the current schedule as "complete chaos” (individual interview). Sage reported that because her timetable was so overloaded, school leadership had arranged to have “a reliever in on one day every two weeks” (individual interview) to allow her time to plan. However, Sage rarely utilised the relief option as preparing work for a reliever was often more time-consuming and frustrating in practical-oriented science classes than losing out on legislated non-contact periods.

Interestingly, in subsequent focus group interviews, whānau also acknowledged the pressure of workload as a realistic hurdle impacting teachers’ ability to differentiate:

> It must be so hard for teachers. You could have 20 odd children in a class. And 80% of them have got different needs and trying to meet everybody's -- You are always going to have somebody that you're not meeting their needs. You can't meet the needs of 20

something people every period, every subject" (mother, year 9 scientifically talented Māori male).

Classroom resources. In addition to time, the other most common theme identified by teachers as a barrier to differentiated teaching and learning was limited resourcing. This category encompassed the following:

- teachers' physical environment as reflected in the following statements: "labs are tiny!" (Turin); "room is a pain!" (Sage); limited access to "gas taps" and "sinks" (multiple teachers) and
- school's organisational environment:
    - inadequate access to laboratories with up to 4 classes timetabled to share 2 ½ laboratories at once (Alton, Sage);
    - minimal access to digital technology block for computer research (Casper);
    - limited/no availability of technician for preparing practical materials (Turin);
    - lack of "money" to buy supplies (Sage, Casper) and
    - competing school initiatives as expressed in Casper's reflection that "Constant PD from outside initiatives [prevents teachers from] actually hav[ing] time to work as a team, innovate, reflect and work in a science group!"

In summary, *Reconnaissance* qualitative findings taken from the open-ended survey responses, classroom observations, teacher planning documents and individual interviews indicate that all participating teachers valued and used a variety of differentiated teaching and learning strategies to meet students' learning needs. However, all participating teachers, including those who described themselves as capable and competent differentiators, reported that they needed to increase their differentiation abilities to extend scientifically talented students and support students with learning difficulties through areas such as interactive process and product approaches. Challenges to differentiation in existing classrooms were described as ranging from teacher workload to the school's physical and organisational environment. The next section of this thesis describes the qualitative themes arising from student and whānau focus groups. As with the quantitative findings, student and whānau perspectives of existing science classroom differentiated teaching and learning both converged and diverged from teachers' views.

Student and whānau perceptions of current practice. The 20 themes emerging from the student and whānau focus groups were categorised by type of classroom environment, as shown in Table 6.4. While the majority of discussion emphasised instructional environment, those facets of the classroom within a science teacher's capacity to directly influence via curriculum planning and implementation, aspects of the structural (physical) school environment and manaakitanga environment were also raised throughout the discussions with students and their whānau.

Table 6.4: *Reconnaissance* Qualitative Focus Group Themes: Type and Number of Responses

Instructional Environment		**Physical Environment**	**Manaakitanga Environment**
Readiness (109)	Collaboration (43)	Digital Devices (27)	Whakamā (33)
Hands-on (98)	Challenge (38)	Ability grouping (20)	Culture (15)
Fun (93)	Choice (36)	Class size (4)	Gender (12)
Variety (51)	Interest (35)	Resources (2)	Trust/Respect (3)
Communication (48)	Authenticity (8)		
Relevance (46)	Pace (6)		

The following focus group findings describe five themes:

- assessment and accommodation of student readiness;
- variety in science teaching and learning;
- relevance of science teaching and learning;
- effective, pro-active communication between teachers and students/whānau' and
- teacher-student relationship and the concept of whakamā.

The first four themes were selected due to their high occurrence and emphasis in student and whānau focus group discussions as highlighted in Table 6.4. Although 'hands-on' or 'practical' learning was also frequently discussed, it is a differentiated strategy for science process variation, so I have embedded it in my discussion of process variety, rather than discuss 'hands-on' learning by itself. Similarly, although the theme of the need for learning to be fun was the third most prominent category, the fact that whānau only mentioned it once led me to integrate students' perspectives of what would make learning fun into the other categories such as process variety or relevance. Other frequently discussed themes such as collaboration, challenge, choice and interest have likewise been integrated. The theme of the teacher-student relationship and the concept of whakamā, although appearing only 33 times in focus group interview conversations, is included in this discussion due to its potential relevance for culturally responsive science differentiated teaching and learning that meets the needs of Māori and other students of non-dominant cultural backgrounds.

To better represent the depth and breadth of the complex perspectives stakeholders held regarding these issues, relevant student and whānau focus group participant direct quotations and student open-ended survey responses are integrated throughout my discussion of qualitative focus group findings, along with applicable classroom observations and teacher interview responses. *Reconnaissance* quantitative findings that support or contradict qualitative findings are also incorporated. I have also included excerpts from Turin's *Planning* and *Acting* classroom observations and individual interviews, for although he began teaching students after the *Reconnaissance* phase (in January, 2016), he joined the teaching staff in the middle of our collaborative planning phase. As the only teacher of Māori descent, his insight into differentiated teaching and learning provided a critical perspective for cultural responsivity.

Assessment and accommodation of student readiness. A key differentiated teaching and learning component emphasised in student and whānau focus group discussion was a need for better execution and implementation of prior assessment of students' scientific knowledge and skills gained from previous schooling years at the college and primary school, as well as life experiences. Prior knowledge assessment was a concern shared by Māori and non-Māori students and whānau of both genders and year groups. A mother of a talented year 8 non-Māori male commented that her son and his peers, "Want the interaction a bit more. They're not blank slates" (whānau focus group*).*

When considering pre-assessment in a focus group discussion, a year 9 Māori female identified as talented in the sciences reflected that her science teacher,

> doesn't ask our opinions on things, just makes us do what he wants and I personally think that an important thing is that the children in the class have a say in what is learnt so at least a few people are interested in the topic.

Her year 9 Māori male peer agreed, "We are not even allowed to get a word in!" A year 9 non-Māori male elaborated that when student voice was actually sought, the teacher "just asks us have we done it and we sa[y] yes and he says okay we will do it again" (student focus group).

Year 8 focus group students voiced similar opinions, with a year 8 non-Māori male student providing his perception of teachers' low value of junior students' input at the school, "Since we are year 8's and last year we were only year 7's we didn't get much of a voice in, in what we are, do, in this school. 'Cause I mean all we had to do was sit there and wait for everything to happen." A non-Māori female year 8 focus group participant regretted that her science teacher "never goes through what our knowledge [is] that we already know" explaining, "never for the subject that we learn . . . we always get the same thing that we already know". These findings confirmed that assessment of knowledge was not as common in unit planning and implementation as it should be (see Table 5.3). Teachers' survey rankings rated pre-assessment of readiness as a value of high importance (*M* = 4.00) but low usage (*M* = 2.00); similar findings occurred among students (value *M* = 4.03; usage *M* = 2.53).

The focus group students who felt challenged in their current science classes tended to be categorised as of average ability by their teachers and reported accurate teacher knowledge of their ability, "[My teacher] challenges me because the amount of work that I do in class he knows that I can do better" (year 9 non-Māori female, student focus group). When reflecting on his differentiated teaching and learning professional development needs and goals, Casper requested assistance with "extension work, provid[ing] new knowledge" as he found it "equally difficult to support differentiation for low- and high-kids" (individual interview). The following sub-sections of this chapter explore (a) how teacher negligence in assessing and accommodating student readiness impacted learners, particularly students of high and low ability, and (b) the wide variance in teachers' use of and response to students' existing knowledge.

Readiness: Impact on scientifically talented students. Certainly, students and whānau identified the lack of pre-assessment and neglect in addressing student readiness led to frustration for students, especially those at the periphery of the academic learning continuum, such as those possessing scientific talent or with learning difficulties. Unhesitatingly, the father of non-Māori children identified as gifted and talented presented his perspective that, "in spite of a teacher's best efforts most of it is pitched at the average kids." He continued,

> These guys [students with low ability] get left behind in a class with everybody and they say, 'What is the point?' and get into trouble. These guys [students with high ability] finish their work . . . . and then they get bored, then they get into trouble.

A year 8 non-Māori female identified by science and non-science teachers as the most gifted student in Year 8 reflected,

> I love science, but I find my teacher is making work at a slower pace that I should be. I'm finding that I'm not being challenged as much as I would like to be. We barely ever do practical experiments anymore and our topic of volcanoes is not teaching me anything I don't already know. This causes me to dread walking into each lesson (survey open-ended response).

A year 8 non-Māori mother of a likewise scientifically talented son identified with such sentiment in the whānau focus group discussion, "My boy is quite curious, so knowing something is important to him. I'll always ask him why do you think that happens? Just to sort of spark off extra thinking." But in discussing science teaching and learning, her son lamented that he was usually "bored [because] he's already done it," and often "finishes too early." A father of two year 8 non-Māori females, also parent to a gifted year 11 student, shared a similar story,

> My boy is in year 11 right now and he has a curious mind. When we are out and about, he is always asking why things work, or how things work or telling me why they work. But

> he has really had his passion for science knocked out of him . . . in the last couple of years particularly.

The father went on to identify the school's "approach to science" as a contributing factor in which his son sometimes was, "spending half of [his] period at school not doing work, twiddling [his] thumbs, [having already] done the schoolwork which my boy particularly finds very frustrating."

Such focus group frustration extended quantitative survey findings in which 74% of students surveyed declared it was important or essential for them to learn new things not just relearn what they already knew, yet only 32% reported that this usually happened in science classes at the school. A year 8 non-Māori male focus group participant commented that he had studied and constructed catapults, with little increase in depth or complexity, for three consecutive years. I observed a year 9 non-Māori male in a discussion with his teacher during a morning break detention explain his motivation for acting up, "We told you we learned this already!" (classroom observation).

Readiness: Impact on students with learning difficulties. Student and whānau focus group discussions also addressed the stress that can result when pre-assessment of students with learning difficulties is absent or neglected. Both Māori and non-Māori focus group participants with learning difficulties such as dyslexia and/or low literacy skills voiced their irritation when science teachers "just expect us to do it. Even though we don't know what [they are] talking about" (year 8 Māori female). A year 9 non-Māori male voiced similar annoyance, reporting that his teacher "is treating us like seniors I think -- he uses big words that we don't even know." A year 8 non-Māori male with learning difficulties voiced concerns over what he viewed as a growing gap between his science abilities and those of more academically able students, "all the undeveloped people just started to fall back a bit while all . . . the people who are advanced just go up and up."

A mother of a non-Māori year 9 male raised concerns over a lack of accommodation in science classes for her son's dysgraphia, reporting he,

> Had been telling me that he was supposed to copy stuff [and] he had to stay a few times at lunchtime because he hadn't finished . . . for him it is just horrendously hard. He is quite a good boy . . . but struggling . . . physically he cannot. It is just too hard for him. A handout is so much better. Or reading it for him is so much better. And then he is free to use all the energy to learn.

In similar focus group remarks the son explained that his science teacher's style of handwriting, "you know the linkage" [cursive] compounded the exertion and time needed for a student like him with dysgraphia in "copying off the board" and interpreting meaning. He wished for more opportunities to "go your own speed and stuff . . . like for me having time is the biggest thing, for my [dis]abilities."

Readiness: Variability in teacher assessment and accommodation. Students and whānau observed that the interest in and responsiveness to student readiness varied greatly by teachers. A year 9 Māori talented female reflected, "My year 8 science teacher was the best science teacher I've had, but as a year 9, I don't enjoy science as much as I used to" (survey open-ended response) further explaining in her focus group,

> So, like last year . . . our science teacher actually made an effort to get to know us better, like letting us talk a little bit, made us, made him know how we are in the classroom and now like [this teacher] doesn't make any effort of getting to know about us.

Classroom observations and discussion with this student's previous teacher revealed little evidence of formalised pre-unit assessment but an emphasis on probing group discussion questions or responsive, flexible, spontaneous and individual interactions with students as they progressed through the unit tasks. For example, modifying or rewording project instructions to assist struggling students in an endangered species online research task. The teacher reflected, "To be effective you have to multitask with kids all the time, being aware and making [responsive, spontaneous] decisions while interacting and intervening" (classroom observations and individual interview).

Students reported the quality of their learning and enjoyment of science was dependent upon a teacher's ability to accommodate student readiness and that the level of responsivity fluctuated greatly among teachers. A year 9 non-Māori female reflected that, "Year 7 was easier because I could understand the teacher and the teacher explained the work . . . year 9 [is] harder because the teacher doesn't explain the work clearly and . . . doesn't know what level I am on." Year 8 student focus group participants voiced like concerns, "I enjoyed last year's science lessons but I really do not enjoy it this year. I am nearly always bored and are almost always relearning things I already know" (non-Māori female). "[Last year] most of the time I got my own special work [but learning this year] has been held back for me 'cause I will have been sitting in a class where I have been doing practically nothing. I already know all the answers to everything" (non-Māori male).

Participating students and whānau had several suggestions for how the school's science teachers could increase the consistency and effectiveness of their differentiation for assessment and accommodation of student readiness to better meet student needs. These suggestions are now explained, with supporting qualitative data excerpts.

Readiness: Student and whānau suggestions for improving assessment and accommodation. A talented year 8 non-Māori female prepositioned, "I think that the work should have different levels of challenge for people who understand it and people that need more help" (focus group). To help teachers gain a better understanding of student readiness, student focus group participants specifically requested that teachers use pre- and mid-unit assessment strategies beyond the commonly used teacher-led group discussion. Students articulated that full class group discussion limited the number of students able to give input, especially in classes of 30+ students, reminiscing, "I remember in primary and we had a class with 13 people in it and it was the most amazing class that we have ever had because people actually had time to speak to the teacher" (year 8 non-Māori female, focus group).

Students widely supported the idea of gathering learner input through the use of individual student surveys, either online or via paper, similar to the 'all-about-me' interest questionnaires that teachers distributed at the start of the school year, but focusing on students' science knowledge and skills. A year 9 non-Māori female focus group participant explained the potential advantages,

> They kind of need a survey or something so everyone can answer their opinions so then people that don't speak up as much can have their say. 'Cause normally when people like speak up . . . like the people that are louder they get, like their ideas like go first.

A year 9 non-Māori male focus group participant agreed but was felt that there was a need to limit what information teachers sought from students to keep differentiated teaching and learning realistic and feasible within diverse classrooms, "Like a survey with four options or something . . . cause you can't get everyone's, so if someone is like wanting to do consciousness or someone else wants to do energy you can't have like all of them in that year."

Students and whānau also encouraged other strategies for determining prior knowledge and monitoring student growth:

- written pre-tests – in building an argument for such assessment, a year 8 non-Māori male focus group participant queried,

  > Why can't we just do some AsTTle[9] test and then that teacher just splits us up into a separate group . . . so everyone who knows this . . . they . . . do a different topic and then if they don't know the topic that we are doing, they do that topic?

- engagement in formal or informal conversation with individual students, particularly in times of transition such as between primary and secondary school, "Like, they could ask,

[9] Ministry of Education assessment tool to assess students' achievement and progress in reading, mathematics and writing and used by the school's English and mathematics departments.

like talk to the students, you know" (year 9 non-Māori female, focus group) or "I reckon like at the start of the year they should interview with the students and ask them what topics they want to learn"(year 8 non-Māori female, focus group).

- learning journals – "Like you could actually journal about what you want to learn" (year 8 non-Māori female, focus group).
- alternatives to sentence intensive assessments for low-literacy students that might involve filling in blanks or drawing pictures (student and whānau focus groups). A year 9 non-Māori female focus group participant observed,

  It's better . . . . when it's typed up, [instead of] when he writes it on the board and you've got to copy it all down. I just want to be able to go, like write '1' and then the answer -- I don't want to copy it all out.

  To which another year 9 non-Māori female responded she enjoyed fill-in-the-blank notes and crosswords, because "We're still writing and doing theory and stuff but it's fun so we want to do it."

In summary, differentiation through assessment and accommodation of student readiness was reported by both student and whānau participants as highly important for creating an engaging science classroom that met learner needs. Student and whānau participants identified high- and low-ability students as those most likely to suffer when assessment of student readiness was neglected in differentiated science teaching and learning. Student and whānau suggestions for improving the consistency and effectiveness of teachers' assessment and accommodation of student readiness included a range of ideas from introductory questionnaires and written pre-tests to learning journals and alternatives to sentence intensive assessments such as drawings or crosswords. The next section of this chapter explores participant perspectives on teachers' use of process variety as a strategy for differentiated science instruction.

***Curriculum differentiation through process variety*.** This chapter section presents the *Reconnaissance* findings addressing variety in science teaching and learning, particularly in regards to differentiated teaching and learning processes. Whānau and students observed that the level of process variety that occurred within a classroom was very "teacher specific" (year 8 non-Māori father) and fluctuated greatly.

Examples of process variation incorporated by the school's science teachers cited by students and teachers and supported in classroom observations included: incorporation of YouTube video clips, teacher-created (original or borrowed) PowerPoint and handwritten notes, baking soda and vinegar erupting volcanoes, catapults, motors, hands-on electronic circuitry experiments exploring patterns in voltage, cross-words, internet-based computer research projects, student presentations, videos, dry ice and balloon practicals, matching activities and tickertape graphing.

Both science teachers and students appreciated the opportunity technology, specifically Internet based resources, provided to extend student learning beyond the classroom walls and school's printed resources, particularly when doing research.

> Last year we did a presentation on specific animals . . . Would kind of like some more of that 'cause we were doing PowerPoints and learning about items that we had never known about before is actually much better than just writing out of a book (year 8 non-Māori male, focus group).

The following focus group excerpts stem from a discussion between Māori and non-Māori year 9 males with learning difficulties, describing how having a "different teacher" caused a big change in the type of process variety they had grown accustomed to in previous years under other teachers.

> "And do you know how . . . last year, [we'd] like do one experiment at least every week?"
> "[Now] we have one like every three months!"
> "Not even that! Worksheets, books, copy off the board . . . . We have to be quiet, like we have to be dead silent, like in year 7 and 8 we didn't have to be, we could talk but -- "
> "We are not even allowed to get a word in!"
> "Yeah, yeah."
> "If you do you will get kicked out!"
> "We just get into trouble."

This dialogue also highlights that a lack of process variety may impact student behaviour and increase classroom management tensions as confusion and boredom set in. A year 8 Māori female similarly observed that variety of process increased her enjoyment of science class,

> I like science, i just don't like how the [current] teacher makes us write heaps of things! Because we hardly do practicals and if we do there boring last year was fun but this year is quite boring, i want more practicals and less writing! (verbatim open-ended survey response).

Indeed, despite teachers' survey responses reflecting a high value (M = 4.33) and usage (M = 3.67) of a variety of instructional modes (Table 5.1), and the previously discussed types of process and product variety incorporated into the classroom, student and whānau focus group discussions indicated that traditional teacher-led, lecture-style, notes-based classwork remained the most prevalent form of instruction in the school's early secondary science classrooms. However, whānau clarified that their perspective of early classroom happenings was greatly influenced and limited by their children's perceptions of science teaching and learning and students' level of openness or lack thereof in sharing their perspectives. The mother of a talented year 8 non-Māori male reported that getting her son to talk about science,

> Is very hard. They mostly talk about what they have done on the playground or what they did at lunchtime or something like that. If you bug them . . . . you hear about the writing side of it: just to listen, taking in information, a bit boring.

A father of three non-Māori children attending the school similarly identified that he viewed an overemphasis on the "idea of sitting still and quiet and primarily writing" as a key contributor to his eldest son's decreasing enthusiasm in the sciences as he progressed through the school. Year 8 and 9 student focus group participants raised related concerns, requesting that early secondary science teachers try to avoid "a full lesson of actual write, like writing full stop" (year 9 non-Māori male).

Both year 9 Māori and non-Māori scientifically talented students and students with learning difficulties requested that teachers prioritise increasing variety of process over other differentiated teaching and learning strategies of content and product, requesting,

> Like we [want to] learn the same thing but in different ways instead of doing the exact same thing. Like when we go in to the science room for science [now], we go in the door, we sit down, and we always get a worksheet every lesson. And then we always listen to [the teacher] talk about something and we just, it's always the same thing (year 9 Māori female, focus group).

Whānau and students recognised that writing was an essential skill for science communication and teaching and learning but wanted to see it integrated a bit more with other ways of learning, particularly 'hands-on' work (see Table 5.3, *n* = 93). In response to another mother's focus group description of her year 9 non-Māori son's dyslexic struggle with writing and preference to "To do experiments and . . . see how it is done [over] . . . . academic stuff" the mother of year 9 talented Māori male commented,

> But you have to try and explain that you need to do a certain amount of the research part, and after the hypothesis and what happened, you've got to do a certain amount of writing. You can't be doing all the time, experiments!

Another whānau focus group participant elaborated, "As long as they get to do the experiment then they will show some excitement in recalling it and writing about it" (father of two year 8 non-Māori females). A year 9 non-Māori male student expressed similar sentiment, "Or just a lot more like, like, class practical – two or one practical a week or something because lately we've been doing none and it's just writing every lesson" (focus group).

A year 9 Māori female focus group participant, like many of her peers, emphasised that increasing variety did not necessarily mean changing the content, but more the approach to how learning was taught in the classroom, "You can like do the same work but like it doesn't mean you have to do it exactly how someone else does it . . . you can't be someone else." Students and whānau shared several ideas for how all science teachers might increase process variety to better differentiate to meet learner need. The most prominent suggestions included increasing variety through:

- more hands-on investigative learning that allowed students to make and learn from mistakes and
- improved teacher and student collaboration.

I explain each of these suggestions, along with supporting qualitative excerpts in the following sections. The next section of this chapter examines perspectives the students and whānau held regarding key characteristics of effective early secondary science 'hands-on' work, often referred to as 'practical' work by teachers, students and whānau.

Increasing process variety: More hands-on, investigative learning. Students emphasised that incorporating student 'hands-on' work into science classroom teaching and learning processes not only increased their enjoyment of science, but also helped them better comprehend and remember key concepts. A non-Māori year 8 female reflected, "Science is good when we have a practical lesson but we don't often have practicals so sometimes that makes it harder to understand" (open-ended survey response*).* A year 8 non-Māori male agreed,

> All of this year all I remember doing was writing down and I can't remember what I wrote. I find it easier to learn if I do hands-on stuff 'cause I find I remember it better. I remember the activities (focus group*).*

Students and whānau reported that more learning occurred in practical work that enabled students to have a go at the activities themselves. Both scientifically talented students and those with learning difficulties pleaded for student-led 'hands-on' experiments, not just video or teacher-conducted demonstrations, voicing frustration when their teacher did "an experiment to show us but we didn't get to do it ourselves" (focus group). The father of two year 8 non-Māori females reported that "doing an experiment by watching a video does not cut it" with his daughters because they "want to do more experiments. Hands-on experiments." However, he clarified that classroom management was a critical component for effective differentiated hands-on learning, "because in order to be able to do experiments safely and to be able to discuss it as a class there has to be discipline in place."

Talented students, especially, voiced a need to be given the freedom and time within their junior science classrooms to perfect, experiment and tweak their hands-on activities, rather than be expected to act as teaching assistant to help other struggling students reach a minimum performance level. A talented year 8 non-Māori reflected, "'With that battery thing . . . I would have liked to just have, if you are finished . . . then you can help, it is not like when you are nearly finished you have to help someone" (focus group).

Less prescriptive and more open design, investigative experimentation were the requests of several year 9 student focus group participants, including both those identified as scientifically talented and those with learning difficulties, who wanted room for curiosity and exploration. Students described the typical junior science practical as very recipe-oriented, “Like normally, like [the teacher]’ll like write the instructions up on the board and make us copy them in our books and then we’ll practically just like do it.” Year 9 Māori and non-Māori females wanted teachers to “not tell us every single thing to do. Have them [instead] trying to make us figure out what we need to do next, like, to be able to get the ending result (focus group)”

Both talented and struggling science students expressed a desire for more student-led inquiry style projects that involved student choice of topics, as demonstrated in this focus group excerpt from a discussion of year 8 Māori and non-Māori males of mixed abilities “It will be real interesting, ‘cause I mean, yeah, you get to do your own thing, you get to choose your project” (year 8 non-Māori male). Both Māori and non-Māori whānau of talented year 8 and 9 males similarly identified projects as a potentially effective strategy for increasing process variety and improving their sons’ science engagement, “Maybe if they could pick a thing for a project. Free choice at some stage. Just to interest them and they can get involved in it and it's more important to them to find out.”

The opportunity for students to make and learn from mistakes was another key aspect of effective student practical work particularly raised by female student focus group participants who found it discouraging and frustrating when they perceived their teacher, “Doesn’t really trust us with anything, like we will do an experiment and if we do something [the teacher] will say it is wrong and will just take over and like just do it himself” (year 9 Māori female).

Whānau support of a learning atmosphere that, while safe and disciplined, encouraged students to take learning risks and clarify their understanding, or lack thereof, through questioning, was reflected in comments such as, “I think [teachers] should say ‘Any questions on that?’ more often instead of saving it to the end,” and “There should be no such thing as a stupid question” (mothers of year 8 non-Māori males).

An openness to teacher and student collaboration was the other key theme, in addition to hands-on learning that was emphasised most by teachers and students as a potential area for teachers to increase process variety to better meet students’ needs. The potential benefits of collaboration are explained, with supporting qualitative evidence, in the following subsection of this chapter.

Increasing process variety: Improving teacher and student collaboration. Qualitative data indicated that both students and whānau valued the opportunity for students to engage in on-task dialogue with their teachers and peers in science teaching and learning, rather than sit quietly. This perspective aligned with the Aotearoa New Zealand Curriculum nature of science competencies of 'investigating in science' and 'communicating in science' in which students are to "work together to share and examine their own and others' knowledge" and "begin to use a range of scientific symbols, conventions, and vocabulary" (p. 52). Whānau observed, "They are more social beings at that age. They want the interaction a bit more" (mother of year 8 talented non-Māori male). A Māori year 9 male with learning difficulties expressed similar sentiment, "Yeah. I like talking and doing my work at the same time."

A whānau focus group suggestion was made to include "paired-peer learning [as done in] primary school" (mother of year 8 talented non-Māori male). A quiet year 8 Māori female who hated speaking in front of the class likewise identified the opportunity to partner with a more confident speaker as helpful, "like pair with peers because you feel more confident and comfortable. At least you're not alone." Whānau also encouraged teachers to "mix the groups so the seating plans and all that gets them out of their comfort zone. You know [as a competent teacher] on the outside looking in, you can probably see who might benefit from working with who" (mother of year 9 non-Māori male with learning difficulties). Indeed, the mother's son likewise reflected in his focus group on how clarification and patience of a gifted year 9 non-Māori male classmate had encouraged his learning, "Yeah if I didn't have [him] … like I probably would have still been in year 7 or 8. I probably would not have understood all the stuff."

Year 8 and 9 students voiced the opinion that peer conversations, when on-task, actually increased the efficiency of learning in the classroom as demonstrated in the following focus group excerpts:

> When like [the teacher] will be talking to other people and you need help so you go to someone else who already knows what they are doing. Then when you go to them the teacher is like, 'No, no, you go back! And, and, you wait for me!' And he takes *forever*! (year 9 Māori male with learning difficulties).
>
> When we are trying to figure out what it is so we talk to someone [then the teacher] will always tell us to shush. We are like trying to understand it with our friends and he's already busy and they are already trying to understand it with their friends and then he'll just tell us to shush (year 8 non-Māori female).

In contrast to the teachers' quantitative low importance rating (*M* = 3.67) and low usage (*M* = 2.00) of 'emulate real science: peer review/debate' (see Table 5.2), focus group participants indicated that discussion and debate were viewed as valuable tools for learning. This value aligned with the Aotearoa New Zealand Curriculum science capability (Ministry of Education, 2015), 'use evidence' in which "learners support their ideas with evidence and look for evidence supporting others' explanations" (para. 5). A year 9 non-Māori male observed, "I like a big discussion with the class . . . . because a lot of people have different point of views . . . so it's more of a funner argument."

In summary, *Reconnaissance* qualitative findings indicated that variety of science teaching and learning process occurred, at varying degrees and levels in science teachers' existing classroom practice. However, students and whānau reported that teachers tended to typically use theory-heavy, lecture-orientated, traditional teaching methods that emphasised taking or copying written notes. Student and whānau suggestions for increasing process variety to better meet early secondary science students' needs emphasised opportunities for students to conduct hands-on, investigative experiments and collectively collaborate with peers and teachers. The next section of this chapter examines participant perspectives regarding the relevance of teachers' science teaching and learning content, products and processes.

Relevance of science teaching and learning. My qualitative results supported quantitative findings (Tables 5.1 and 5.3) that teachers, students and whānau all highly valued science teaching and learning that was relevant to students current or future lives (Table 6.3, n = 46). A year 8 Māori female focus group participant summed up the importance of relevance quite simply, stating, "Don't expect me to learn when I don't know why."

I chose to probe relevance of science teaching and learning in my qualitative interview questioning due to the difference in quantitative teacher and student survey perspectives regarding teachers' incorporation of relevant science knowledge and skills. All three teachers had reported linking what they were teaching to students' "real" lives 'often' or 'frequently' (M = 3.33) but 59% of students reported that teachers 'never' or only 'sometimes' did so.

Qualitative *Reconnaissance* findings indicated that relevance of science content, process or product was viewed by teachers, students and whānau as:

- connecting to students' lives,
- providing foundation of skills and knowledge for upper secondary success and
- preparing students for adulthood.

Explanation and supporting qualitative evidence of these themes are provided in the following sub-sections of this thesis and were shared with teachers in the collaborative *Planning* phase. Because my qualitative findings indicated a perceived disconnect among many students and whānau between what students were learning and what was relevant to lives outside of classroom, much of the content of the following subsections focuses on not what teachers were doing well, but describes student and whānau suggestions for how teachers could increase the relevance of students' learning during the MMAR *Planning* and *Acting* phases.

Improving relevance: Connecting to students' lives. Students and whānau both reported a need for teachers to increase the relevance of what was taught in science classes to students' current lives outside of school. A whānau focus group participant conveyed that a common complaint of her scientifically talented Māori son was, "All the stuff they teach you, why do we have to learn that stuff? You're never ever going to use it!" She explained that he viewed a lack of relevance to be a problem for not only science classes but school in general. A mother of a year 8 non-Māori son voiced similar sentiments, stating her son continually questioned, "Where is my practical bit Mom? What are we doing that for? That doesn't do anything!"

The ideas students and whānau in focus group discussions had for increasing relevance to connect with students' current lives were organised into three categories: (a) student interests (b) community connections and (c) cultural inclusion are explained in the following sub-sections of this chapter. Each category is briefly explained as follow.

i. Building connections: Incorporating student interests. Sage reflected that her teaching strength was "I know the kids individually quite well. They feel relaxed with me and will share things, even stuff outside of school" (individual interview). She cited that having grown up in the community she had the advantage of "knowing families, sports, etc." and could incorporate "close local examples" such as "hot water beach" for geothermal discussions (individual interview).

Quantitative and qualitative findings revealed that, overall, students agreed with Sage that teachers at their small school did know learners and their interests well with 54% reporting that their science teachers 'usually' or 'frequently' 'know what I am interested in' and only 8% responding 'never/hardly ever'. However, the incidence with which students viewed teachers' incorporation of student interest into classwork, was much lower with 39% reporting 'never/hardly ever' or 'unsure'.

When asked if student interests were incorporated into their science classes, a year 8 Māori male reported "for sports, yeah" while his two year 8 non-Māori male peers responded emphatically, "No! Not at all. But I'd like them to be incorporated." It seemed that whether or not teachers incorporated students' interests depended on what the students' interests were. A year 8 Māori female reflected, "In science we just do what everyone else does that's interested." A mother observed that teacher neglect in incorporating student interest could lead to learner disengagement, reflecting that her year 8 Māori daughter "is okay at science if she applies herself, but yeah, if it does not interest her she won't even try."

Students reflected that incorporation of interest varied by teacher and class. Year 8 Māori and non-Māori girls had noticed the accommodation of supposed 'boys' hands-on interests in the newly formed all-male year 8 class and were upset because they felt they were missing out, "It's like so not fair. They will be making volcanoes and we'll be sitting in science the whole-time writing. We never get to do anything. . . . The sad thing is that [the boys' class] has the same teacher as us and [they do] more fun things than we do."

The females voiced the importance of equity for gender in covering similar material in equally exciting ways for all students. They observed, "each class do funner things than our class this year" (year 8 Māori females). A year 8 talented non-Māori male focus group participant suggested that rather than using wooden cars and ramps when testing motion, they could have increased relevance and interest by, "driving an actual car."

Year 9 focus group participants reflected that they felt their interests had been better incorporated in their early years of science at the college, "Like for people that like sports he would take, he took us out to the sports field and do like timed things or something" (year 9 non-Māori male). In reflecting on other teachers, a year 9 talented Māori female responded, "if we are in other [non-science] classes they will ask us subjects or things that we want to work on or something."

Engagement and incorporation of student interests were evident during my classroom observations of Sage's year 10 unit on genetics and reproduction. Spontaneous student-originated questions were encouraged and explored in class discussions as Sage and her and students revised for end-of-year assessments. Sample questions included the following:

- "Can you sneeze and a baby comes out? I saw it on TV."
- "Can you imagine us as parents?"
- "What age is good for babies?"
- "Miss, did you see that girl on 7 Sharp [news media] with no bum?"

The teacher initiated a discussion with students, linking their topic of the male reproductive hormone testosterone to current events regarding the recent disqualification of the female Russian Olympian in her victory over Aotearoa New Zealand shot put champion Valerie Adams. Indeed, topics of human reproduction, or at least female anatomy seemed to be of interest to year 9 males in particular.

A year 9 talented Māori female in another teacher's class reflected,

> There was actually one experiment that we did in science this year that I actually did enjoy but we have had the opportunity to do it ourselves but it was still quite interesting. Like we got our dry ice and . . .you get like with dishwashing liquid and put it in the water and you put the things in [balloons]. It was probably the coolest thing (focus group).

Her year 9 male peer responded, "Yeah that was cool as, I made boobs. (Laughter). It was pretty funny. Then we got kicked out."

As Alton demonstrated when I observed his years 9 and 10 classrooms, the ability to modify pre-planned lessons with spontaneity was essential to responsively meeting learner needs and incorporating student interests (I.e. allowing peer support during individual assignments). Sage, too, reflected in her individual interview that whereas in her early years of teaching she "used to plan by term in detail" she now "[used] lesson unit plans and makes modifications to meet year group/fit my strengths . . . [going] by what the kids actually do, learn, [and] need to know."

ii. Building connections: Community links. Students and whānau expressed the view that strengthening connections between science classrooms and the local community could potentially increase teachers' effectiveness of facilitating a differentiated science teaching and learning curriculum that met students' needs and was relevant to students' lives outside school. Two themes emerged from student and whānau focus group discussions in relation to this topic and are explained, with supporting qualitative data, in the following paragraphs:

- authentic connections with parents and experts in the community and
- field trip excursions.

Both students and whānau encouraged teachers to expand direct connections between the science classroom and the local community. Suggestions started small, "have science outside the classroom just on the grounds. You could find a project" (mother, year 8 non-Māori male). Others included involving whānau support and expertise, "I don't know if parents want to be involved but maybe that's how you get your kids moving more as a parent if you're interested and all that stuff" (mother, year 8 non-Māori male).

Suggestions for connecting science classroom learning to local infrastructure within the rural community from whānau included: (a) "the farm, that's real life and in the community", (b) "the dairy milk factory might do something", (c) "the hydro: the geothermal" and (d) "Rotorua museum." Student focus groups discussed building connections between junior secondary science students and younger students at local primary schools. A year 9 Māori male reflected that something he enjoyed at primary school was a field trip to another school's science fair,

> Miss, miss! I remember in my primary school we even got to go to like [the local intermediate school] and like they had the science show thing. They were like kids . . . and they put on this show. And it was 'cool as' and stuff. We should do that!

A year non-Māori 8 male similarly reflected that an extension opportunity for talented secondary science students could be the option to share completed inquiry projects with primary school students directly across the road, “Well I mean what we could do is we could have the intelligent people go off to the primary and teach some of the primary kids for a bit.”

Another option suggested for connecting students’ science learning to local and regional scientific and ‘real-life’ communities was getting students out on more field excursions, as no years 7-10 science field trips had occurred in 2015. “I think we need a field trip for science,” a year 8 Māori female focus group participant proposed. However, after further discussion with her year 8 Māori female friend, the two cautioned, based on their experience earlier in the year while on a trip for another subject, that all field trips needed to link clearly to what was being taught and learnt at school. They explained, “For the field trip that we did for [another subject] I didn't even know why we went.” They observed, “We weren’t studying [the topic/place].” The students found it quite embarrassing when interacting with experts on-site during the field trip, “Like the lady, she would ask us questions and hardly anyone knew because we weren't studying it.”

Year 9 student focus group participants had conflicting views of their only science field trip at the school, a year 7 physics unit excursion that involved testing friction and the speed of different materials while sliding down the hydro-slide at a local hot pool. “We should do more stuff like that,” reminisced a year 9 non-Māori female, while a year 9 non-Māori male reflected, “That was boring!”

Suggestions from whānau for year 9 field trips that could be pertinent to their children’s recent astronomy topic included incorporating science into the existing EOTC framework (which minimised cost), “They've been doing the planets and that and we were talking about going at year 9 camp, about going to Auckland, to the what do you call it? [Stardome]” (mother, year 9 non-Māori male). Whānau also discussed connecting with a local astronomy club that the school’s GATE students had already established a positive relationship with, “There's a good group in Whakatāne, [students] just need to get there” (father, year 8 non-Māori female), elaborating, “You know me, I’ll go on anything. . . Quite happy to be a parent helper which gives them the opportunity to go.”

Student focus group participants expressed similar ideas, ““Like to go to the, the planetarium in Auckland or whatever” (year 9 non-Māori male) but also were willing to dream beyond school and whānau budgets as demonstrated in the following dialogue between two year 9 non-Māori females,

> “We should go for a trip to space. That would be cool!”
> “Go to the moon!”
> “I don’t want to die though. . .”

Whānau focus group participants discussed the importance of communication between teachers and whānau to better enable whānau to support community-connected learning. The father of two year 8 non-Māori females reflected, "I know it is hard to get parents along, too. But you can't if you don't give it a try." This topic of communication between stakeholders is explained more in depth under the communication section of this chapter. The next sub-section addresses the concept of differentiating classroom environment, content, process and product to connect with student cultural backgrounds.

iii. Building connections: Cultural inclusion. On quantitative surveys, all teachers ranked knowledge of student cultural background and inclusion of Māori contexts as important or essential (*M* = 4.33). However, both quantitative and qualitative data demonstrated varying opinions among students and whānau in regards to the relevance of science teaching and learning to students' cultural background practices and the need for its inclusion in science education. When students were asked to respond to the statement, 'Science is relevant to my culture,' 46% on the science attitude section of the quantitative survey responded they were 'unsure', with the remaining 54% split evenly between 'agree' and 'disagree'. A similar response was observed in response to the statement, 'Science is relevant to my whānau'; 42% responded 'unsure', with 31% agreeing and 27% disagreeing.

On the importance and usage section of the survey 57% of student survey participants declared that they 'didn't care' or felt linking cultural background into science classwork was 'unimportant' (*M* = 2.42), but 28% declared it 'essential'. Teachers, likewise, shared mixed opinions (*M* = 3.67) on the importance of integrating cultural understanding in science teaching and learning with one stating it was somewhat 'important', another 'important' and a third 'essential'. Interestingly, teachers viewed by Māori and non-Māori students as least responsive to students' needs were those teachers who reported cultural integration as the least important. "I think some of the science teachers should consider and think about our ideas that we share instead of just throwing it out the window" voiced a year 9 Māori female focus group participant when reflecting on teaching and learning in her current science classroom.

Both Māori and non-Māori focus group participants expressed views for and against bicultural inclusion in the sciences as demonstrated in the following excerpts from focus group discussions. Some whānau felt it important for science teachers to integrate diverse "cultural practices around the world" (mother, year 8 non-Māori male). Others questioned the merits of culture impacting classroom environment, content, process or product: "Why would it [science teaching and learning] be different? Science is science!" (mother, year 8 non-Māori male). When questioned by other focus group participants, this same mother who first appeared against bicultural inclusion acknowledged integration of non-dominant cultures in science teaching and learning could be beneficial, “Yeah different cultures have got different explanations for the names of the stars and why they were called what they were called. . . cultural differences.”

Student focus group responses either did not address bicultural inclusion directly, or when asked, supported the inclusion of Māori culture in science education, arguing it should have priority over dominant cultures such as Chinese or Spanish (the two foreign languages offered at the school in 2015).

> “Yeah I would really like to do a bit more Māori stuff in science cause like I mean that’s our least likely subject to do anything” (year 8 non-Māori male).
> “It’s [Inclusion of Māori culture] important with Aotearoa, yeah” (year 8 non-Māori male).
> “We go on our two cultures so we can -- I think we should learn the Māori culture before we do anything else like Chinese or…” (year 8 non-Māori male).

Whānau suggested that topics such as genetics and astronomy could provide meaningful contexts for introducing bicultural or multicultural perspectives. However, non-Māori whānau members wanted to ensure that European culture was not excluded from bicultural navigation units that discussed sea navigation or waka (traditional Māori canoe) movement, “The British and then Europeans used to navigate by stars as well” (father, two year 8 non-Māori females).

As the only Māori science instructor at the school, Turin discussed the importance of including Māori perspectives on any bicultural initiatives within the department, reflecting,

> I think that they're a little bit too culturally sensitive [at this school]. This is coming from a brown person. . . . Maybe they're just trying to go too brown? . . . As Māori, we see this stuff and think, ‘Okay, this Māori initiative is driven by a Pākehā. What Māori would want to do this? It was drive by a Pākehā in a university, those people love this!”

Turin maintained that the critical factor for increasing Māori learning was not modification of content but being fair and keeping expectations high, “Don't let them get away because they’re 'down-trodden.'”

In summary, the diverse *Reconnaissance* perspectives shared by participating teachers, students and whānau on the importance and strategies for cultural inclusion for differentiated science teaching and learning indicate that incorporating cultural relevance is a challenging task, particularly for non-Māori science teachers. The next sub-section describes a topic that Māori and non-Māori teachers, students and whānau more readily agreed upon, the importance of learners obtaining skills and knowledge needed for success in NCEA.

Increasing relevance: Foundation for upper secondary success. Whānau reported valuing the potential for science teaching and learning to grow life skills’ attributes that would help students achieve in higher levels of schooling and beyond, including “teaching them to be responsible young people and look after their own information” (father of two year 8 non-Māori females). Student focus group participants, however, particularly those with older brothers and sisters in years 11-13, were more concerned about the specific skills needed to pass NCEA.

Students expressed a desire for explicit connections in what they did and learned in years 7-10 science to what they would need to do to be successful in future NCEA work. In regards to product, these students requested “end-of-year” (year 8 non-Māori female) or “end-of-term” (year 8 non-Māori female) mock exam practice so they would not panic when presented with their first NCEA external exams, science or otherwise, at the end of year 11. “I reckon it would be much better because then we will all be able to see what exams are like” (year 8 non-Māori male). The only mention of NCEA, specifically, in whānau focus group discussions was from the perspective of a mother of a talented year 9 Māori male, who felt the complexity of year 9 work was not what she expected in preparation for NCEA in little over a year away, “You know I am surprised at the minimum homework or the lack of homework I thought there would be a bit more work in preparation for NCEA.” A mother of a talented year 8 non-Māori male new to Aotearoa New Zealand secondary schooling reflected that, whānau as well as students, needed support in transitions, “I feel the new mum thing. Where everything is new to me in the high school thing.”

Qualitative classroom observations and interviews of science teachers revealed a commitment by teachers to providing a strong foundation for junior students to successfully continue in senior science classes both within the general science class at level 1 and the domain-specific levels 2 and 3 biology, physics and chemistry courses. All observed teacher lessons were derived from department selected units that not only addressed a breadth of Aotearoa New Zealand Curriculum (2007) science content strands of the ‘living world,’ ‘planet earth and beyond,’ ‘physical world’ and ‘material world’ but also ‘nature of science processes’ including understanding, investigating, communicating and participating/contributing. Examples of topics covered in observed classes included: (a) living world – photosynthesis (year 9), human genetics and reproduction (year 10), and the impact of habitat loss on animal species (year 9) and (b) physical world – forces and motion, and electricity. The concerns of teachers, students and whānau alike seem to be encapsulated in a simple statement uttered by a student focus group participant, as summarised by his hopes for NCEA preparation and upper secondary work “We want to not be surprised when it comes up like, oh, hell, how do you do this?” (year 8 non-Māori male).

While qualitative findings indicated an emphasis of teachers and students on the relevance of science teaching and learning in providing learners with the knowledge and skills needed for NCEA success, participants also valued the relevance of science teaching and learning for preparing students for success outside of school. The next subsection further describes qualitative findings exploring the importance of relevant science instruction that prepares students to be successful adults, even if they end up not pursuing NCEA science studies or a science-orientated career.

Increasing relevance: Preparing students for adulthood. Whānau focus group participants viewed science as a relevant topic for students to learn not only for future academic success but as a foundation for their future careers and successful lives as adults. “I think a lot of people think it's just buffoons in a laboratory and all, don't they? And it's not that at all” reflected the mother of a year 8 scientifically talented non-Māori male.

Whānau described examples of science in their everyday lives: (a) “All your farming, huge of farming” (mother, year 9 non-Māori male); (b) “Like putting chlorine in your swimming pool. You know that it's actually salt. And so, what the difference between saltwater and the swimming pool and the chlorine pool. All that sort of thing” (mother, year 9 non-Māori male) and (c) “Yeah, like the biology part of nursing” (mother, year 8 non-Māori male).

The only student reference to learning in relation to a future career was brought up by focus group participants discussing student motivation for completing classwork or meeting deadlines and how they felt they it would likely improve when they were entered the workforce,

> As kids, we don’t necessarily take [classwork/deadlines] seriously because we know it’s school. We’re not going to get like fired from school. And I get that schools are education but I think like when we get a job we’ll take it more seriously, I mean, because we need the money (year 9, non-Māori female).

The fact that year 8 and 9 students did not discuss science teaching and learning as relevant to their future careers in any focus group comments or open-ended responses on the surveys did not discourage whānau, “I think probably that you don't realise how important science is for your career when you are at school” a mother of a year 9 non-Māori male with learning difficulties reflected, continuing,

> And anything like farming, nursing, even! ‘Cause I was a radiographer. And I went and . . . we had to do so much science. And I wouldn't have actually picked that. And I know my girlfriend worked at a dairy factory and she went and did a science degree after. But, yeah, all those sorts of things. Science is so important but we probably actually don't put the emphasis.

In summary, my *Reconnaissance* qualitative findings indicate that teachers, students and whānau all highly valued science teaching and learning that was relevant to students’ current or future lives. Although participating teachers reported selecting and teaching content knowledge and skills relevant to students’ current and future lives, and classroom observations typically supported teachers’ claims, most students and whānau believed relevance of science teaching and learning needed to be improved. Suggestions for increasing science content, process and product relevance included (a) connecting to students' lives through student interests, community connections and cultural inclusion; (b) providing foundational skills and knowledge for upper secondary schooling success including NCEA and (c) preparing students to be successful, competent adults. Student and whānau perceptions of science relevance and the applicability of existing science teaching and learning practices to learners' lives, as well as suggestions for improving the relevance were shared with teachers during *Planning* phase collaborative differentiation unit development sessions and formed the foundation for many of the changes teachers implemented during the *Acting* phase. The next section of this chapter describes participant perspectives on the impact of communication for increasing or limiting effective differentiated science teaching and learning.

Communication for differentiation. Qualitative findings revealed that students and whānau viewed communication to be an essential component of effective differentiated science classrooms. Participating teachers, likewise, brought up the topic of communication within the department and between management of the school and teachers as a key contributor or hindrance to effectively differentiating science teaching and learning that met students' needs. Communication themes developed from participants' perspectives gathered through open-ended survey responses, classroom observations and interviews were divided into two major categories, (a) within school communication and (b) communication between the school and home. Both of these areas are now described, using supporting qualitative data, in connection to differentiated science teaching and learning.

Within school communication. The majority of qualitative data collected on communication for differentiated science teaching and learning discussed communication strategies used or neglected within the school setting. The three dominant 'within school' communication themes were identified as (a) between teachers and students, (b) among teachers and (c) between school and home. These themes are explained more in depth in the following subsections.

i. Communicating within school: Between teachers and students. Quantitative survey responses (Table 5.1) indicated that teachers (M = 4.67) and students (M = 3.92) alike valued science instruction grounded and articulated in clear learning objectives and reported that it occurred often in existing classroom practice (teachers' M = 4.00; students' M = 2.79). Certainly, students identified 'having a marking schedule with clear expectations' as a strength (usage M = 2.72) of many science teachers. Most written science department unit schemes or teacher lesson plans identified learning objectives (classroom observations). However, years 9 and 10 teacher classroom observations and student focus group discussions also revealed inconsistency in how teachers articulated and communicated these objectives to their students, ranging from specifically written on the board or verbally introduced to implied or missing.

For example, year 8 focus group students reflected on the value of knowing the aims and objectives of science lessons, “And I liked it when [our year 7 teacher] put up on the board like the ‘AIM.’ What you're actually gonna do” (year 8 non-Māori female). “Yeah!” responded her year 8 Māori female peer elaborating,

> We didn't think it was a good thing at the time because we didn't want to write it but it helped us so much like now we don't do that so [the teacher]’ll just be like, explain it to us and you're obviously going to forget. It's hard to remember all of it. Then [year 7] we had to write it down and take our books. And it was like good because you could just look at your book and just remember because it had your ‘AIM’, like what you want to do, and what you wanted it to look like and stuff and needed. And then you did the conclusion at the end.

A teacher participant likewise reflected that clearly articulating objectives “is something I need to do better” suggesting that, “I probably need to write in my book” to remind myself to clarify lesson and unit objectives with students (classroom observation follow-up interview).

Year 9 focus group participants identified that a teacher’s willingness to and aptitude in communicating information to students either positively or negatively impacted students’ collective and individual ability to learn and varied from teacher to teacher. The following focus group excerpts demonstrate that student capacity to comprehend what a teacher is communicating can be affected by cadence, vocabulary and order of explanation,

- “He speaks too fast” (year 9 non-Māori male with learning difficulties);
- “Sometimes they tell you the hard way instead of saying it is so easy” (year 9 Māori male with learning difficulties) and
- “[The teacher] doesn’t explain it in the right order that he should explain it in, like, he explains it all over the place” (talented year 9 Māori female).

Students expressed annoyance when they perceived that a teacher “has favourites as well” (year 9 Māori female) and appeared to routinely address only a subset of the classroom, rather than everyone, during group instruction, as evidenced by this statement from a year 9 Māori female, “When he is talking and explaining something to the class he only actually says it to a few people, like some people in the front.” To which a year 9 non-Māori male replied, “Yeah, so like my desk is here and then there is the front desk but [the teacher] only speaks to the people here and doesn’t speak to us and the girls.” Whānau focus group participants similarly expressed appreciation for teachers who monitored all students’ learning and, “Go around the classroom in the lesson. Wanders over there and there at the back. Have them walk around, ‘How are you going with that? How you going with that?'" (mother, year 8 non-Māori male).

In summary, participating teachers, students and whānau perceived both strengths and weaknesses in how the school's science teachers communicated with their students. While teachers and students perceived that most existing science instruction was grounded and articulated in clear learning objectives, they also cited room for improvement, particularly in communicating learning aims for daily lessons. Students identified that science teachers' ability to differentiate their communication through both verbal and non-verbal components such as cadence, vocabulary, explanation style, eye-contact, body gestures and movement around the room greatly influenced students' ability to understand and learn science content.

The views that whānau and teachers held regarding the potential influence of communication between teachers within and across disciplines are now presented in the context of promoting effective differentiation for not only students with learning difficulties, but also those across the learning spectrum, including the scientifically talented.

ii. Communicating within school: Between teachers. Whānau and teachers reported that increased teacher-to-teacher communication (ideally across disciplines but at a minimum within the science department) would potentially increase teachers' ability to differentiate effectively to meet individual science students' needs, particularly regarding three key areas: (a) content and skill acquisition, (b) individual learning needs and (c) academic records.

A year 9 mum observed discrepancies among science teachers for how student academic records were utilised from year-to-year. She voiced her confusion over whether it was best to annually approach each of her son's teachers regarding strategies for his high-energy, dyslexic approach to learning or assume the knowledge had been passed on by previous teachers.

> I had to [intervene again this year] because he's not supposed to be copying stuff down with his [disability] from the whiteboard and things . . . [My son] had been telling me that he was supposed to copy stuff because he had to stay a few times and at lunchtime because he hadn't finished. . . I sort of thought it would have been well documented around his teachers.

Casper reported that, although experienced in teaching, because he was new to the school, access to more detailed "schemes of work would be helpful" in preparing lessons that best met early secondary science students' needs (individual interview). Turin, who did not join the school teaching staff or science department until 2016, shared similar frustrations when describing his first few weeks as an experienced teacher new to the school,

> Mostly I would like learning objectives so that I know where we are headed. That helps me plan more. Seems to be difficult to get in this department . . . Also, there was no pre-test for the first unit, I would like to make sure there is some type of probing of prior knowledge to help with responsive teaching (individual interview).

However, it should be noted that in his reflections of the transition to teaching in the school as a new teacher, Casper also acknowledged that he “felt very supported this year [2015] by the HOD [Head of Department]” declaring the science department staff to be “great people.” Indeed, Alton reported that his own preparation time for teaching and learning, differentiated or otherwise, was restricted by the time required to communicate with, mentor and support new and/or non-science trained faculty teaching [in 2015] at all levels of the department [years 7 - 13] (individual interview).

In summary, communication was reported as actively occurring within the science department. However, improvements in how teachers gathered and shared student information and planning documents were perceived by whānau and teachers to have the potential to enable more effective differentiated teaching and learning in science classrooms. The next subject of this chapter explores the gaps in communication between school management and teachers reported by teachers as hindering their ability to differentiate effectively to meet student need.

iii. Communicating within school: Between management and teachers. Teachers declared frustration and confusion over what they felt were unarticulated and/or ambiguous management expectations ranging from unit objectives to the location and format of school staff and community meetings. Teachers reported strong vision, clear communication and on-going support from school leadership as critical components to growing their capacity to differentiate in their classrooms.

Changes to timetables (shifted or dropped classes) after the school year began were especially demotivating for teachers that had been excited to implement the materials they had created for those classes over the summer. Casper reflected,

> I have [had] rough times this year . . . This year is the first time I’ve taught junior science. I didn’t think I would be teaching the younger students or these subjects when I agreed to take the job. I was surprised to see general junior science on my timetable . . . I am a traditionalist by training and expertise (lecture-orientated) but it is not working here. The game plan here is different (individual interview).

He reiterated that the “Head of Science has supported me greatly this year, without him, I wouldn’t have been able to do it” (individual interview).

Turin shared similar frustrations as an experienced teacher new to the school,

> Communication seems very weak from the top . . . Senior management aren’t really good with communicating . . . there's nothing coming from them. Can't really blame them. I know they've got lots of stuff they have to carry down. It's seems to me that each department is left to their own device. You know there's no direction coming from leadership . . . I'm still lost! (individual interview).

Although Sage had seven years of experience at the school, she also reported a need for more pro-active communication from management, especially in regards to advance notice of teacher subjects and class lists for the next year's teaching schedule. She felt this would enable her to better differentiate to meet the needs of her science students at all levels, not just early secondary. Sage lamented that even two weeks from the end of the school year, "I have no idea what will be next year!" (individual interview) specifically in regards to whether her passion area of "junior agriculture science would be integrated" (individual interview) into year 9/10 science classes or its own separate identity, a critical component for planning ahead to facilitate outside of school practical applications and 'real-life' connections within the local farming community

In an interview following my classroom observations of Sage's year 10 lesson human reproduction, she further explained that because she knew the community and students well, "Knowing [from management before the start of the new school year] who is in classes and what classes we are teaching" would mean I could "utilise this time [Term 4] with seniors away" to prepare and "could plan over summer" to better differentiate to meet individual students' needs for 2016.

Indeed, student focus group participants voiced similar desires, requesting that they receive their timetable before the start of the 2016 school year 'like at primary school' to allow them to better prepare for their classes,

> With the end of the year we don't get our new timetable until the new year and as year 9s we don't know what to bring. Some people don't have enough room in their bags. Teachers expect us to know what to bring and we don't have our timetable (year 8 non-Māori female).

This very topic of communication with whānau from school levels of management, department, and individual classroom and its impact on whānau capacity to support student differentiated learning is discussed in the following sub-section of this chapter.

Communication between the school and home. Whānau repeatedly emphasised the need for better communication between the school and home to enable whānau to support teachers' differentiation to meet students' needs. Whānau focus group participants expressed an interest in receiving pro-active communication from the science department regarding topics studied, exam dates, homework expectations or field trip opportunities well ahead of time rather than receiving information with a week's notice, or after that fact in reports or conferences, as "it helps with our [family] planning" (mother, year 8 non-Māori male). Whānau expressed that knowing what their children were studying enabled them to establish better relevance "links into dinner time discussion around the table sort of thing" (mother, year 9 non-Māori male). A single mum of four secondary students reflected that advance communication was especially critical for her as she faced particular financial and time crunch challenges in raising her children, “I have to juggle everything out.”

Despite wanting to support the school and her son’s learning, this mother felt that a lack of knowing what was happening ahead of time resulted in, “Well I mean all year I have not been involved with anything [academic]. A mother of year 8 non-Māori male further agreed, sharing her perspective that she only really heard from teachers when things with her son were really bad or really good, “It's like a factory. We don't know what goes on in the factory . . . We are out of the loop. [Teachers] only come to us with a problem or a brilliant [stand-out achievement!] And that's it!”

Several year 9 focus group participants reflected that one of the “real consequences” that motivated them, as well as many other students, to stay on-task and avoid misbehaviour in early secondary classrooms was the threat of teachers going to parents with such problems. “Oh, parents find out, parents finding out, yeah” (year 9 non-Māori female) via “ringing home . . . everyone’s scared of that!” (year 9 non-Māori female). Although one student reflected, “Some people don’t care,” all members of this year 9 focus group affirmed it mattered to them, “I get scared … [when] my parents find out.”

Whānau were open to both traditional (informative letters, e-mail, phone calls) and less traditional media (websites, texts) for school-wide and departmental updates regarding “anything that's going on that we ought to know” (mother, year 8 non-Māori male). The whānau participant who was also serving on the school board observed that differentiating to meet the needs of the school’s diverse whānau required, “A mix [of digital and print communication] though because there are [multiple] communities involved in our school. They don't have the online access. So, unfortunately both sides have to be covered.” Many recommended the school newsletter, that although sporadic, presented a potential established platform that could be utilised more efficiently by teachers, “Yeah [school’s newsletters] are quite good and they're just in the post [or e-mail] so you're always guaranteed to get it. It's not stuck in their school bag” (mother of year 9 non-Māori male).

The results of this chapter section indicate that effective communication – between teachers and students, among teachers, between management and teachers, and school and home – was viewed by participating teachers, students and/or whānau as an essential tool for enhancing differentiation efficacy in science classrooms. Qualitative findings regarding a teacher’s role in student development and how the teacher-student relationship is critical for effective teaching and learning are now explained from the perspectives of teachers, students and whānau.

Teacher-student relationship and the concept of whakamā. Qualitative findings supported quantitative results (see Table 5.1) that indicated a component of differentiation of high importance to teachers and students alike is a positive classroom environment in which teachers know and value students as individuals and ground responsive curriculum modifications of content, process or product in this knowledge. Whānau focus group participants agreed, explaining that the difference between teachers that held or did not hold genuine relationships with their children was evident, even in the limited communication they received in their "5-minute appointment" time slot at parent conference nights.

> I think as a parent we need the teachers. When we are talking to them and you have a teacher that's, ahh [daughter's name], let's see (ruffle through papers). Oh, here she is! Whereas if I say [her name] to you, you can list a page of what she is like. Just knowing the child, it comes across! Yeah (father of non-Māori year 8 females).

Turin identified that observing and personally interacting with learners was essential to establishing strong relationships and determining how to differentiate curriculum for learners in his classroom at a new school. He reflected, "A year 7 male scored off the charts [pre-assessment] but when you talk to him he cannot communicate well at all, so tests can be a starting place, but observations/interactions etc. are also helpful" in determining how to best differentiate (individual interview). Similarly, Turin had noticed in the first three weeks that a "year 9 [Māori] boy in the low literacy class should not be there" and would likely need "work that he can do at home to challenge himself without letting his mates know he is doing it (to save face) 'cause he will be quite bored at the pace everyone else is working."

When I asked Turin if being Māori helped with connecting to the Māori students, Turin responded, "Yes, but only initially. To maintain respect, students want you to know your stuff and care about them." Turin described the importance of a blend of compassion and structure in the classroom. Although he originally cited "biology" as his science teaching strength, later in the individual interview he admitted that "being an Alpha male that takes no crap in the classroom" was probably his teaching strength, combined with "treat[ing] students with respect and expect[ing] the same." His teaching experiences in both rural and metropolitan Aotearoa New Zealand schools led him to the conclusion that, "Too often, teachers lower expectations of Māori students when they should be challenged instead."

The notion of the importance of 'saving face' identified by Turin, particularly in regards to cultural responsive teaching for Māori students, is represented in my *Reconnaissance* qualitative focus group themes (Table 6.3) by the Māori term, whakamā (n = 33). Te Aka Online Māori Dictionary (2017) translates whakamā "to be ashamed, shy, bashful, embarrassed" but Sachdev (1990) declares there is no "exact equivalent in Western societies" (p. 433) for this Māori behavioural construct that encompasses multiple aspects of feeling inadequate or inferior, self-doubt, extreme modesty or withdrawal. Sachdev (1990) distinguishes whakamā as a critical construct to comprehend for anyone seeking a greater understanding of the interactions of Māori among Māori as well as between Māori and non-Māori. Interestingly, although the term whakamā did not appear verbatim in any qualitative data, its concept was a concern expressed not only by Turin but also by Māori and non-Māori students (particularly year 8 females) and whānau focus group members alike.

When asked, "What keeps you from doing well in science class?" year 8 focus group Māori and non-Māori females identified "judgemental comments," tone, or body gestures of "both" teachers and peers that they interpreted as "just put[ting] us down." Examples cited included when "[the teacher] rolls his eyes at us" or "give[s] you that look." They elaborated, sometimes "you ask [the teacher] a question [and he'll] be like [gesture of putting hands up] and he "would just act like it was the dumbest question." Or, "I hate when you're trying to present in the class when some of the boys will be like, laugh at you, if you do something dumb." The females identified that the wide range of student knowledge and mixed-ability within their science classes (of 30 students) complicated the problem, "Like there are people who really struggle in our class. And then there's people that find it way too easy" (year 8 Māori female). So, "[The ones that find it easy] they treat other people like they're dumb" (year 8 non-Māori female). "Yeah if you do something wrong the boys are like, 'Ahhh, shame! I got a higher score than you!'" (year 8 non-Māori female).

Interestingly, Turin, the only teacher of Māori descent, was the sole teacher to discuss the importance of the classroom environment as a venue for students to seek answers to legitimate questions, regardless of their complexity or lack thereof, "I try to run classes where it is a safe place, where people feel okay to ask dumbass questions. If it's a genuine dumbass question, they can do that" (teacher interview).

Indeed, in addition to an atmosphere that encourages responsible risk-taking and learning from mistakes described earlier in this chapter, student focus group responses indicated a high value in the need for respect of individual student privacy and confidentiality. This was particularly the case in the differentiated area of product when students' knowledge or skills were assessed. Student and whānau focus group participants raised time and again the importance of not singling out students for lack of knowledge in front of their peers, an action viewed as "really embarrassing," whether intentionally or unintentionally committed by teachers or peers.

A year 8 Māori female reflected on one such particularly embarrassing situation from year 8 science,

> Like one time we are watching a movie and I didn't understand the point of watching the movie so I just sat there and didn't do much. And then [the teacher] paused it and I said, 'What's happening?' And then she was like, 'Well *you* need to pay attention, [student's name], because you're the one that didn't get a really good mark on your test.' In front of the whole entire class!

Her year 8 peer and friend, elaborated, "Yeah . . . And then we started talking 'cause we were like talking about the movie. [The teacher] said, "You two better shush just because youse didn't get good marks" (year 8 Māori female).

A non-Māori year 8 female continued,

> It happened in year 7 as well. Like [the teacher] would single them out. And like . . . would like make you feel really dumb. And like so when you ask a question she'll be like [gesture] just act like it was a stupidest question in the world.

Students also recalled situations where they, themselves, hadn't been singled out, but expressed a feeling of whakamā empathy for others. A non-Māori year 8 female described a day when her teacher incorporated lollies for revision, which the student initially thought was good idea except, "then [the teacher] said if we got it right we got to eat one. But one person didn't get it right and they were not allowed to eat it and everyone else was . . . It was kind of sad."

Whānau recalled experiences from their youth with similar frustration in the following excerpt, "A sarcastic teacher you remember it for the rest of your life. There should be no such thing as a stupid question" (mother, talented year 8 non-Māori male). Time and again, whānau expressed their respect for the science and non-science teachers who they viewed as competent, compassionate educators at the school. When attempting to close the focus group interview, whānau agreed that the following conclusion summarised their understanding and expectation of differentiated teaching and learning for early secondary science teachers and students, "[We're] not expecting super teachers but just knowing that there are times when [our] child's needs will be on the forefront. [We] know it might be that week or that project. Then there will be another kid that's at the forefront."

Summary

In this chapter I introduced the rationale for and procedures utilised in *Reconnaissance* qualitative data collection and analysis: classroom observations, individual teacher interviews and focus group student and whānau interviews. Findings from my qualitative instruments were shared to more fully understand the quantitative findings regarding stakeholders' perspectives on differentiated teaching and learning presented in Chapter 6. Teacher perspectives on what constituted differentiation, personal competence and confidence in differentiation, current differentiation practice and barriers to effective differentiation were shared. Key themes that emerged in student and whānau focus group interviews were also discussed: (a) assessment and accommodation of student readiness; (b) variety in science teaching and learning; (c) relevance of science teaching and learning; (d) effective, pro-active communication between teachers and students/whānau' and (e) teacher-student relationship and the concept of whakamā. Meta-inferences derived from integrating these qualitative findings with the quantitative findings described in the Chapter 5 will next be introduced, along with implications for the *Planning* and *Acting* phases, in Chapter 7.

Chapter 7:

Planning and Acting

He pai te tirohanga ki ngā mahara mō ngā rā pahemo engari

ka puta te māramatanga i runga i te titiro whakamua.

It's fine to have recollections of the past but wisdom comes from being able to prepare opportunities for the future.

This chapter begins with the key meta-inferences derived from integration of the quantitative and qualitative strands of *Reconnaissance* data collection and analysis. It then presents the methods and findings for phases 3 and 4 – *Planning* and *Acting* – of my MMAR investigation. The primary objective of the *Planning* phase was to answer research question 2, "How can teachers work together collaboratively with a researcher to incorporate stakeholder input from teachers, students and whānau when planning differentiation of the science curriculum?" Research question 3 provided additional focus for the planning process as the teachers and I sought to determine, "How can the principles and practices of differentiation for gifted and talented students be adapted to understand, inform and implement differentiation of the science curriculum for all learners?" Subsequently, the *Acting* phase was guided by my fourth research question that attempted to establish, "How do teachers implement a collaboratively-designed plan for differentiation of the science curriculum?"

In answering the research questions, I discuss the following MMAR (Ivankova, 2015) *Planning* and *Acting* components:

- sharing of *Reconnaissance* findings with stakeholders;
- teachers' collaborative development of a differentiated year 9/10 science unit (action plan) in response to findings and meta-inferences derived from teacher, student and whānau *Reconnaissance* data and
- implementation of the differentiated science unit (action plan) designed in response to *Reconnaissance* meta-inferences.

Reconnaissance Meta-Inferences

The term 'meta-inference' refers to a conclusion that emerges from the integration of qualitative and quantitative data collection and analysis in mixed methods research (Ivankova, 2015; Onwuegbuzie & Johnson, 2006; Tashakkori & Teddlie, 2009; Venkatesh, Brown, & Sullivan, 2016). Ivankova (2015) observes that adherence to meta-inferences is critical throughout a MMAR study to "promote cohesiveness and integrity" (p. 298). Carefully derived meta-inferences assist participants in gaining the "necessary knowledge and strategies to address the next step in the problem-solving cycle when seeking a desired solution for the issue at hand" (p. 298).

Integration of my quantitative and qualitative *Reconnaissance* findings led to the development of four meta-inferences that influenced my MMAR study's *Planning* and *Acting* phases. The *Reconnaissance* meta-inferences address both the characteristics of and challenges to effective differentiated science teaching and learning and are displayed in Table 7.1.

Table 7.1: *Reconnaissance* Meta-Inferences Derived from Integration of Qualitative and Quantitative Findings

1. A responsive learning environment is critical to effective differentiation.
2. Differentiated science teaching and learning is implemented variably by individual teachers.
3. Effective science differentiated teaching and learning presents many challenges.
4. Differentiation should respond to teacher, student and whānau perspectives of student need.

Reconnaissance meta-inferences, the links to supporting mixed methods evidence and implications for the *Planning* and *Acting* phases are described, individually, as follows.

A responsive learning environment is critical to effective differentiation. Participating teachers, students and whānau asserted that a responsive learning environment was critical to meeting diverse student needs. Table 7.2 displays the quantitative survey and qualitative interviews excerpts that best depict the importance community members placed on responsivity. As Table 7.2 shows, Sage, Alton and Casper highly valued the need to adjust teaching to meet students' needs (M = 4.67); students tended to emphasise the importance of teacher assessment of students' existing skills and knowledge (*M* = 4.03) to ensure that content and level of classwork were new and challenging (*M* = 3.97). The qualitative quotes in Table 7.2 provide insight into the reasoning behind participants' expressed high importance for spontaneity, pacing, knowing students and scaffolding.

Table 7.2: Mixed Methods Evidence Supporting *Reconnaissance* Meta-Inference 1

Meta-inference 1: *A responsive learning environment is critical to effective differentiation*.		
Quantitative Evidence		**Qualitative Evidence**
• Teachers reported that adjusting teaching to meet student need was essential or important (*M* = 4.67).	Teachers	"To be effective you have to multitask with kids all the time, being aware and making decisions while interacting and intervening" (Alton, individual interview).
• Students highly valued teachers testing individual student's knowledge to determine what "I already know" (*M* = 4.03) so that all students were "learning new things" (*M* = 3.92).	Students	"Different people learn at different paces . . . so, I think that we all need to like have it the way that we like learn best or stuff like that" (year 9 non-Māori female, focus group).
• Students highly valued teachers challenging individuals to grow and excel (M = 3.97).	Whānau	"As a parent, we need the teachers . . . knowing the child, it comes across!" (father of two year 8 non-Māori females). "A hand-out is so much better . . . then he is free to use all the energy to learn . . . For him to sit and write uses up all his energy" (mother of year 9 non-Māori male with dysgraphia).

The majority of qualitative conversations emphasised the importance of a flexible, responsive instructional environment – based on student readiness – when differentiating for effective student science learning. Figure 7.1 displays the variety of differentiated strategies articulated by focus group participants as essential to responsive teaching and learning. As it shows, student and whānau discussion frequently raised the need for greater assessment and accommodation of student readiness. Also, frequently discussed was the importance of incorporating hands-on learning in science classrooms, often referred to as ''practicals" or "experiments". While students often discussed the need for learning to be fun, whānau focus groups and teacher individual interviews tended to instead emphasise the importance of relevance to content, process and product.

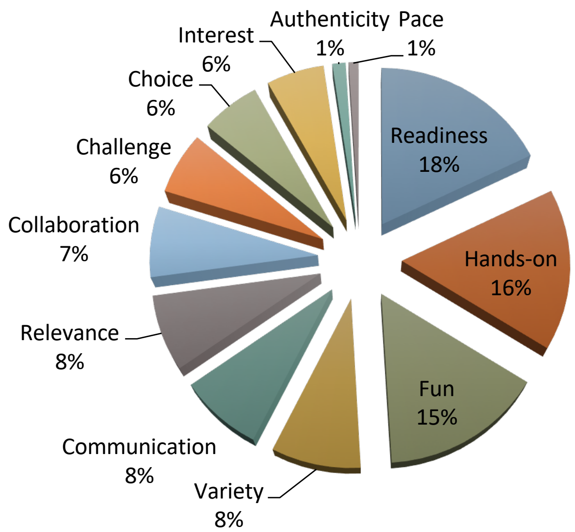


Figure 7.1: Focus group instructional environment differentiation strategies grouped by topic (*n* = 611 responses).

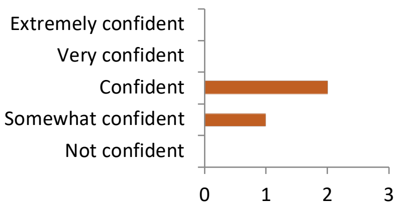
Differentiated science teaching and learning is implemented variably by individual teachers. Teachers, students and whānau reported that differentiation occurred in existing science classrooms (Table 5.1: high value/high usage). However, as highlighted in Figure 7.2, participants observed that the type and extent to which differentiation was implemented varied greatly by teacher. Individual teachers reported using differentiated strategies that ranged from modifying content type or quantity to process differentiation (teacher interviews). Teachers and students tended to compare and contrast students' current and previous science learning under different teachers to explain their perceptions of effective or ineffective differentiation.

Meta-inference 2: ***Differentiated science teaching and learning is implemented variably by individual teachers.***

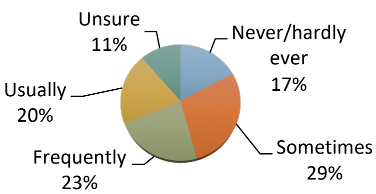
Quantitative Evidence

• 100% of teachers reported incorporating differentiation in current year 9/10 science teaching and learning

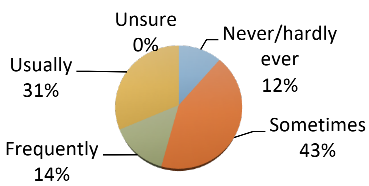
• Teachers' self-ratings of confidence and competence in differentiating the science curriculum:



• Students reported science teachers challenged them to grow and excel (survey):



• Students reported learning new things in science class (survey):



Qualitative Evidence

Teachers

"[Differentiate] sometimes. . . Will usually have extra work for those who finish early. For those who struggle I have minimum requirements that I help them" (Sage, open-ended survey response).

"[Differentiate] often through teacher pupil interactions. Setting work aimed at the mid upper end of the class then promoting access to the work through teacher interactions with the lower ability while questioning the upper ability students to extend their learning beyond the main learning objectives"(Alton, open-ended survey response).

"I found it unsustainable to engage every learner in diverse ways in every lesson (Casper, open-ended survey response).

Students

"So, like last year our science teacher. . . made an effort to get to know us better . . . how we are in the classroom and now like he doesn't make any effort of getting to know about us" (year 9 talented Māori female, focus group).

"Last year . . . was actually better because [our teacher] took the advanced kids and actually did different practicals with them but with the people that still needed help he actually helped them a bit more" (year 8 non-Māori male, focus group).

Whānau

"It is very teacher specific" (father of year 8 non-Māori 8 females).

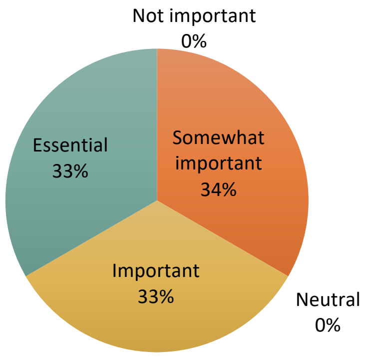
Figure 7.2: Mixed methods evidence supporting *Reconnaissance* meta-inference 2.

Effective science differentiated teaching and learning presents many challenges. As highlighted in Figure 7.3, teacher, student and whānau participants also recognised that meeting all science students' needs was a challenging task for teachers – science or otherwise. Participants indicated that teachers should not be expected to differentiate to meet each individual student's needs and/or interests every day. Barriers to differentiation identified by participants ranged from teacher workload to limited classroom resources.

Meta-inference 3: *Effective science differentiated teaching and learning presents many challenges.*

Quantitative Evidence

- Although students (M = 3.81) and teachers (M = 4.00) alike rated accommodation of learner difficulties as important, students reported that teachers seldom knew (M = 2.35) or addressed (M = 2.15) student difficulties (surveys).
- While teachers reported highly valuing (M = 4.67) and often using process variety (M = 3.67), students reported that teachers only sometimes did this (M = 2.44) (surveys).
- Diverse teacher perspectives on the value of integrating cultural understanding into inclusive differentiation (survey):



Qualitative Evidence

Teachers

"What we would like to be doing and teaching our students can be different to what actually is taught and how, due to lack of time for preparation" (Sage, open-ended survey response).

"None [differentiated PLD] in past 5 years that was effective. In teacher training, there was lots of theory, occasional examples, but not much practical (Alton, individual interview).

Students

"They don't really have enough resources . . . because they don't have enough room in the sciences" (year 9 non-Māori male, focus group). "If someone has like wanted to do consciousness or someone else wants to do energy you can't have like all of them in that year!" (year 9 non-Māori male, focus group).

Whānau

"It must be so hard for teachers. You could have 20 odd children in a class. And 80% of them have got different needs . . . . You are always going to have somebody that you're not meeting their needs. You can't meet the needs of 20 something people every period" (mother, talented year 9 Māori male).

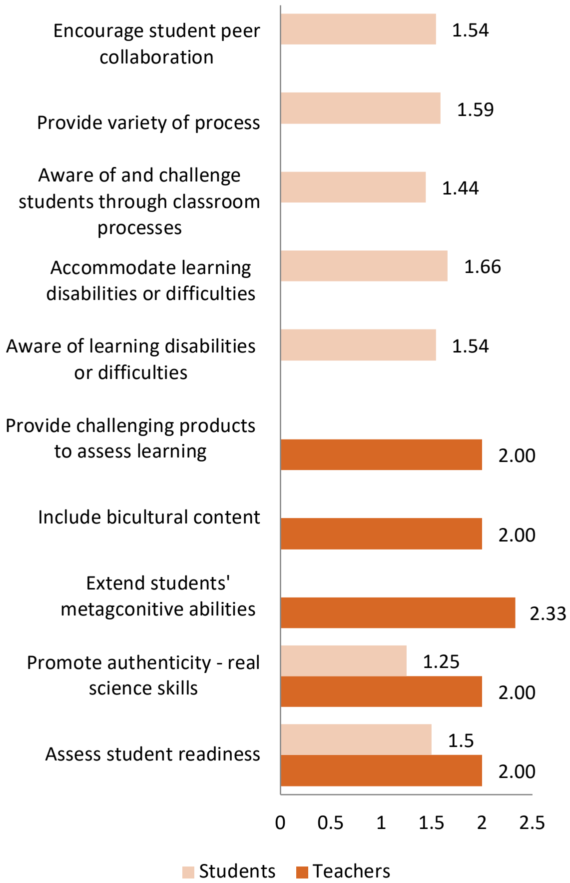
Figure 7.3: Mixed methods evidence supporting *Reconnaissance* meta-inference 3.

Differentiation should respond to teacher, student and whānau perspectives of student need. Teachers, students and whānau participants asserted that teachers would better be able to meet students' needs if they focused on incorporating differentiation components viewed by the community as having high value and low usage. Figure 7.4 shows the differences in means of survey responses for differentiated strategies rated of high value and low usage (taken from Table 5.3). Larger numbers represent a wider gap in participants' views of high importance and low usage, thereby indicating differentiation strategies with a perceived greater potential to increase teachers' ability to meet year 9 and 10 science students' needs. Qualitative quotations are also incorporated into Figure 7.4, further explaining participant perspectives on what the focus for change during the *Planning* and *Acting* phases should be.

Meta-inference 4: *Differentiation should respond to teacher, student and whānau perspectives of student need.*

Quantitative Evidence

Differences in survey mean responses (least usage subtracted from highest value) for differentiated strategies reported by *Reconnaissance* teacher and student participants as having the most potential to increase teachers' ability to meet students' needs. Larger numbers indicate greater potential for change.



Qualitative Evidence

Teachers

"Would like to reinforce or correct what I think I know about differentiation with current up-to-date examples, especially interactive process approaches" (Alton, individual interview).

Students

"I love science, but . . . I'm finding that I'm not being challenged as much as I would like to be. We barely ever do practical experiments anymore and our topic of volcanoes is not teaching me anything I don't already know. This causes me to dread walking into each lesson" (talented, year 8 non-Māori female, survey open-ended response).

"Since we are year 8s and last year we were only year 7s we didn't get much of a voice in, in what we are do in this school – all we had to do was sit there and wait for everything to happen"(year 8 non-Māori female, survey, open-ended response).

"Have them not tell us every single thing to do – have them trying to make us figure out what we need to do" (year 9 non-Māori male, focus group).

Whānau

"Being able to relate it to living now – our everyday experiences. Or how the branches of science are in everyday life" (mother, talented year 9 Māori male, focus group).

"You get the 'school's you know, it's boring. All the stuff they teach you why do we have to learn that stuff? You're never ever going to use it!'" (mother, talented year 9 Māori male, focus group).

Figure 7.4: Mixed methods evidence supporting Reconnaissance meta-inference 4.

Assessment of student readiness and promotion of authentic, 'real science' skills were the only two components viewed by both teachers and students as areas needing improving to better meet science students' needs. Students' indication of a need for more variety in science teaching and learning processes (difference = 1.59) directly contradicted participating teachers' views that providing variety of process was a teaching strength (see Table 5.1: value M = 4.67. usage M = 3.67). Table 7.3 shows a summary of the differentiated areas identified in student and whānau focus group discussions as having the most potential to improve science teaching and learning.

Table 7.3: Summary of Differentiated Areas Most Discussed by Student and Whānau Focus Group Participants as Having Potential to Improve Teachers' Ability to Meet Students' Needs

Science differentiated teaching and learning component	*n* (number of comments)
Teach knowledge and skills relevant to students'	117
- current lives: interests, community, culture	
- upper secondary schooling	
- future adulthood	
Assess and accommodate student readiness	109
- talent, disabilities, prior knowledge and skills	
Incorporate variety and choice of content, process or product	87
- hands-on learning: new, challenging, student-driven, investigative, open to risk/mistakes	
- fun	
Communicate proactively	48
- teachers/students	
- within and across disciplines	
- between management and teachers	
- between school and home	

The key differentiation strategies identified by students and whānau as having the most potential for meeting existing students' needs were:

- relevance,
- assessment and accommodation of student readiness,
- incorporation of variety and choice in content, process or product
- proactive communication within the community.

How I introduced these findings to teachers as well as teachers' response in the *Planning* and *Acting* phases are detailed in the rest of this chapter.

Planning

I initiated collaborative curriculum development and planning in the MMAR *Planning* phase to firstly allow teachers to reflect upon and discuss the *Reconnaissance* findings. Teachers then selected differentiation strategies and protocols to implement when planning a differentiated science unit responsive to stakeholder input. This was followed by the implementation of the differentiated unit plan in years 9 and 10 classes during the *Acting* phase. Qualitative and quantitative findings regarding the overall effectiveness of the unit plan in meeting students' needs are further explored in Chapter 8.

Teacher and researcher collaboration and planning occurred in two group sessions over the summer holidays (December 2015-January 2016) and was supported outside of those sessions by on-going e-mail and phone dialogue between and among teachers and myself as researcher. Collegial mentoring such as that demonstrated in my collaborative planning groups is in line with the Aotearoa New Zealand Ministry of Education's (2015c) *Kia Eke Panuku: Building on Success*, secondary schools' critical cycle of learning (Chapter 4) and mahi tahi (shared power) collaboration initiatives of effective professional development.

Participating teachers (Alton, Sage and Casper) were invited and agreed to take part in the collaborative planning group. I documented both planning sessions with 'descriptive' (what happened) and 'reflective' field notes (what sense was made of the site, people, situation) written by teachers and me (Creswell, 2015a). In addition, I also captured audio recordings of the collaboration for analysis purposes.

My role as researcher in the teacher collaborative planning groups differed greatly from the moderator position I held in the MMAR focus group sessions with students and whānau that followed pre-set (yet flexible) interview question guides. My chief contribution to teacher planning was sharing the meta-inferences derived from *Reconnaissance* qualitative and quantitative data collection and analysis. I encouraged participating teachers to direct and control planning and professional development responsive to all findings, but particularly the areas indicated by science students and whānau as having highest value and least use: (a) relevance, (b) assessment and accommodation of student readiness, (c) incorporation of variety and choice in content, process or product and (d) proactive communication within the community.

School-wide changes post Reconnaissance impacting MMAR study. A decline in student enrolment from 344 to 264 during the course of the 2015 school year resulted in several modifications to overall school management structure and ensuing academic and co-curricular activities over the summer holiday (January, 2016). These modifications resulted in unanticipated changes within the school's science department, which, in turn, influenced the *Planning*, *Acting* and *Evaluating* phases of my MMAR study. Such changes included staffing adjustments and the creation of mixed-year level junior classes. The impact of these changes on junior science classrooms and my overall study is explained in the following subsections of this chapter.

Staffing. A key staffing change impacting my study was Casper's shift from the science department to his area of expertise – mathematics – at the end of the *Reconnaissance* phase (December 2015). The school then hired Turin, an educator of Māori descent with 16 years of science teaching experience (see Chapter 4, Table 4.1). I continued to share research findings with Casper – per his request – throughout the MMAR process but invited Turin to participate in Casper's place for the *Planning*, *Acting*, *Evaluating* and *Monitoring* phases. My rationale for the substitution was that any student or whānau participant providing *Acting* and *Evaluatin*g 2016 feedback would be critiquing current, rather than previous teachers' implementation of differentiated science teaching and learning. Turin agreed to take part in all *Planning*, *Acting*, *Evaluating* and *Modifying* MMAR study research activities. However, in accordance with Smith's (1999) kia tūpato and kaua e takahia te mana o te tangata (Table 3.1), I modified my original research data collection time frame for the *Acting* phase. Turin's introductory interview and classroom *Acting* observations were delayed to allow Turin time to establish himself within the school community first.

Merging of junior science classes. Another change impacting my study was the school's introduction of mixed-year junior level classes. Over the summer, school leadership combined all years 7 and 8 classes and, likewise, merged all years 9 and 10 classes, in response to reduced staffing funding from the Ministry of Education. The merging resulted in fewer junior science classes overall. Within these science classes, the teachers chose to implement between-class flexible grouping. Science contact hours were increased by 30 minutes (years 9/10) and 1.5 hours a week (years 7/8).

The merging of classes influenced teacher timetables with Alton no longer scheduled to teach years 9 or 10 science classes. Because Alton was still keen to contribute to and learn from the on-going MMAR professional development of differentiated teaching and learning within junior science classes, we agreed that Alton could remain in the MMAR investigation, incorporating differentiated teaching and learning with his years 7/8 junior science classes instead of years 9/10. As such, any classroom observations of Alton in the *Acting* phase actually occurred within years 7/8 classes.

Merging of junior classes alleviated some differentiation challenges in the *Planning* and *Acting* phases for teacher participants. Fewer junior science classes overall increased teacher and student access to science laboratory (1 teacher per laboratory) and digital technology access (computer room, iPads, microscopes), making it easier for teachers to incorporate differentiation for variety of process and product, particularly for hands-on learning. The combining of junior classes also reduced the number of different science classes taught by individual science teachers (teaching years 9/10 and years 7/8 together as two grouped sections instead of four separate ones), therefore decreasing the number of classes for which participating teachers prepared. This meant that during the *Planning* and *Acting* phases of my study, participating teachers collaboratively planned and implemented one year 9/10 differentiated unit, rather than two separate years 9 and 10 units as intended in the original research design.

Merging of junior science classes also created new challenges for teachers during the differentiation planning process, particularly in regards to determining student readiness. Because the 2016 year 10 students had already learnt much of the school's established year 9 content, teachers needed to, in general, avoid that subject matter. However, year 10 science content introduced in the mixed 9/10 classroom needed to be scaffolded to assist year 9 students with only years 7/8 background. Merging of classes also created the potential for new social dimensions as learners worked with students outside of previously established, familiar, peer groups. Participants' perspectives, both positive and negative, on the merging of junior science classes' impact on learning environment are shared in the *Evaluating* findings of Chapter 8.

Despite the unexpected changes, differentiation remained a priority for participating teachers. The collaborative planning teachers undertook to achieve their differentiation goals is explained in the following sections of this chapter.

Collaborative planning session 1. The initial collaborative planning session occurred in December during the first week of the school summer holidays. Alton, Sage and I, in my supporting role as researcher, participated in the two-hour cross-curricular department planning. The purpose of the planning session was to share and discuss *Reconnaissance* results as a way of informing teacher planning. Data collected included collaborative planning documents (unit and lesson plans, e-mails, online and text resources), researcher observations, field notes and audio recordings. Findings from these resources as well as teacher discussions are explained in the following subsections of this chapter.

Sharing key Reconnaissance differentiation findings. I first shared a summary of *Reconnaissance* findings and meta-inferences with teachers, highlighting both the strengths and weaknesses of the science department's 2015 approach to early secondary science differentiation as perceived by teachers, students and whānau. Teachers were encouraged that all groups of stakeholders agreed that (a) teachers personally knew individual students well and (b) science was a potentially valuable and enjoyable school subject. We discussed strategies for improved differentiated science teaching and learning as identified by student and whānau (high value/low usage):

- increased relevance of knowledge and skills to students' current and future lives,
- better assessment and accommodation of student readiness,
- greater variety and choice in content, process or product and
- more proactive communication between/among stakeholder groups throughout the year.

My approach to leading professional development in this research was in the form of a critical friend – informal and driven by teacher input. In retrospect, this role could have been stronger. I provided a selection of Kanevsky's (2013) toolkit and additional science resources in response to Alton's request for materials related to how to differentiate science process and products (see Appendix Q). These included (a) student process and product options, (b) prompts for open-ended, high-level thinking tasks and (c) differentiated chemistry and biology lesson exemplars. My study did not measure the impact of using those resources on teaching practices.

Identifying differentiated goals for Planning and Acting phases. Teachers chose to focus on three of the four suggested areas to differentiate, specifically targeting differentiation for:

- content relevance through connections and applications to students' 'real lives' outside of school,
- assessment and accommodation of student readiness (pre/mid/post unit)
- and variety and choice in process and product with an emphasis on more hands-on learning.

Teachers based their decisions on (a) stakeholders' high value in the differentiated strategy; (b) self-reflection of personal areas needing professional growth; (c) perceived relevance of strategy to students' future science schooling and (d) anticipated feasibility of implementation based on predicted resources, class size and teacher workload. Because *Planning* and *Acting* teacher participants did not share the student/whānau perception that ineffective teacher communication was a key barrier to differentiated student learning in their classrooms, they chose not to address pro-active communication as a differentiated strategy needing improvement.

Forming a deferential differentiated science unit responsive to community input. Participating teachers next mapped a tentative year plan to increase relevance through fostering meaningful integration and development of students' STEM content and skills. Alton and Sage chose a year 10 biology topic – human body systems – as the term 1 unit for science differentiation and, as such, the focus for this MMAR study. Topics selected for subsequent 2016 year 9/10 science curricula included: (a) forces and motion (physics), (b) acids and bases (chemistry), (c) genetics and reproduction (biology), (d) electricity in the home (physics) and (e) local area investigations (ecology, geology).

Alton and Sage reflected on the previous year's human body lesson plans and activities to determine which areas to modify in 2016 to meet their current MMAR differentiated science unit targets. To increase the relevance of science content and applicability to students' lives outside of school, teachers discussed shifting their teaching emphasis away from the biology of the human body as a network of systems to a practical, 'essential first aid' approach of "What goes wrong? Why? How to fix it?" Alton and Sage determined key system organs and functions would be more relevant if addressed through a disease or injury approach. Examples included heart attacks, strokes and bleeding (circulatory system); diabetes (excretory system); asthma (respiratory system); broken bones or soft tissue injuries (musculoskeletal system) and allergic reactions (immune system).

Alton and Sage discussed the prospect of individual student research projects as a viable way to increase product variety and student choice. Suggestions included (a) conducting case studies of a whānau member or famous person suffering from a human body system dysfunction/illness/injury (such as Jonah Lomu, Aotearoa New Zealand All-Black legend who died of kidney failure in November 2015) and (b) exploring tikanga Māori [bicultural inclusion option] or homeopathic approaches to prevention and treatment of human disease/injury. In response to student and whānau *Reconnaissance* input requesting greater assessment and accommodation of student readiness, Alton and Sage also committed to implementing unit pre-assessment via survey or written test format.

Because Alton was no longer timetabled to teach years 9 or 10 students, Sage took over Alton's position as lead years 9/10 junior science teacher. Sage agreed to develop teachers' differentiated human body systems unit brainstorming into a unit overview in preparation for the next collaborative planning session. The second collaborative planning session occurred in January, one day prior to the commencement of the new school year and is detailed next.

Collaborative planning session 2. Alton, Sage, Turin and I all partook in the three-hour voluntary science department differentiated planning meeting. We began the planning session by introducing Turin to the:

- school's overall science curriculum;
- MMAR study and *Reconnaissance* meta-inferences and

- science department's differentiated targets for the upcoming year 9/10 human body systems unit: (a) increasing relevance, (b) improving assessment and accommodation of student readiness and (c) providing greater variety and choice in process and product.

Sage and Turin committed to addressing these differentiated targets in their planning and implementation for year 9/10 science classes, which ranged in size from 14-28 students. Sage and Turin both differentiated the human body unit for two year 9/10 classes each (total of 4 classes). Alton, no longer timetabled to teach year 9/10, incorporated the differentiated targets into his years 7/8 class.

In addition to the department's differentiated aims, each participating teacher set informal, individualised differentiated professional learning goals. Alton aimed to extend the type and level of challenge he offered scientifically talented students. Sage wanted most to increase her ability to respond appropriately to students' diverse readiness needs. Turin identified that much of a teacher's transition to teaching in a new school comes down to survival in the first term – figuring out how everything works in a different environment. As such, Turin determined to focus on increasing his ability to meet student readiness by developing solid teacher/student relationships in an environment that promoted manaakitanga. He cited safe, controlled and fun as personal priorities for developing a responsive differentiated classroom learning environment.

Teachers identified several remaining obstacles to planning for differentiated planning for the 2016 school year, despite students arriving the following day:

- incomplete or incorrect student class lists meant that teachers were unable to determine which students would be in their classes and could not adequately plan for learners' needs before the school year started;
- undeveloped school calendar made it difficult for teachers to know when to schedule in advance more complex community relevance connections, variety of process activities and readiness assessments that required liaison with out-of-school resources (guest speakers, hearts from butchers for dissection) or student mastery of prior learning knowledge/skills;
- uncertainty around department funding for resources meant teachers could not order class materials ranging from practical supplies (chemicals, beakers) to student texts and
- unreliable utilities (water, power, Internet) made it difficult to plan for variety of process activities that required digital technology or water for clean-up (dissection).

Further developing a deferential differentiated science unit responsive to community input. Alton, Sage and Turin spent a substantial amount of the second planning session addressing logistical issues, such as calculating the available lesson/laboratory time for students under the new timetable. Teachers reported the amount of time available for instruction impacted not only the selection and depth of content, but also the variety of content, process and product they could offer students. The applicability and relevance of what students would be learning and doing – particularly year 10 students – to their future NCEA level 1 science studies was another guiding factor for teachers when selecting unit content, process and product.

Sage presented the human body systems differentiated unit draft she developed over the summer in response to the first *Reconnaissance* collaborative planning meeting – an overview of potentially relevant content, processes and products to be incorporated over the course of the term (Appendix R). Sage's unit summary consisted of an updated version of human body components that teachers had identified in the first collaborative planning session as essential for homeostasis (maintaining equilibrium in the human body) and survival. Under each component were a list of subtopics, potential hands-on activities and/or experiments and links to students' lives or pertinent current global, national or community events identified by teachers as potentially relevant to learners. For example, the *excretory system* was selected as a main topic, under which *kidneys* and *dialysis* were listed as subtopics, *dissection* as a potential hands-on activity, and *Jonah Lomu* as the relevant current event. Teacher discussion relevant to their differentiation targets of (a) increasing relevance; (b) providing greater process variety and choice and (c) improving assessment and accommodation of student readiness is shared in the following chapter sections.

Increasing relevance. In the second collaborative planning session, Turin agreed with Alton and Sage's content focus on survival and the use of a disease/injury approach to link the biology content of the human body systems unit to students' current or future lives outside of school. Teachers discussed the incorporation of outside community "experts" in first aid or rongoā Māori (traditional Māori medicine). The potential of a field trip to local Pilates studio or sports-training gym was also raised.

Teachers reiterated the need to ensure that students' years 7-10 science experiences prepared students adequately – in knowledge and skills – for the rigour of NCEA senior level science classes. Teachers observed that senior science subjects of biology, chemistry and physics required domain specific content and methods mastery. Therefore, when selecting content, teachers considered not only what was required of Aotearoa New Zealand junior curriculum science components and strands (Ministry of Education, 2007) – nature of science, living world, planet earth and beyond, physical world, material world – but also NCEA achievement standards used in senior science classes. This approach would help achieve academic content relevance.

Also raised was the possibility of creating template(s) for student individual research projects in an attempt to prevent student plagiarism (commonly witnessed as cutting and pasting information directly from websites) and encourage a higher-level of thinking and analysis of evidence throughout years 7-10. Sage and Turin supported Alton's suggestion of a departmental homework policy within the wider scheme of promoting students' study and life skills (organisation, responsibility, time management) relevant for success both at the senior science level and in students' future careers.

Determining and responding to student readiness. Teachers committed themselves to eliciting and incorporating greater student voice and remaining flexible when designing and implementing a differentiated human body systems unit responsive to students' needs. While teachers intended to focus on one human system (respiratory system, circulatory system) or essential body component (heart, lungs) per week, they allowed curricular space and time for modification of content, depth and breadth based on on-going assessment of students' interests and needs throughout the unit.

Teachers decided to create an introductory survey as the means for increasing their awareness of student readiness in relation to prior learning, individual ability, attitude towards science, out of school interests, current and future aspirations, curiosity in planned topics and connections to community experts. The teachers and I also discussed the potential for such a survey to be beneficial for assessing the readiness of 'new' students who might transfer into the community later in the school year. Sage offered to develop the years 9/10 student science readiness survey with my support. I provided Sage with Kanevsky's (2011b) *Possibilities for Learning Survey* and digital copies of previous junior science class introductory student readiness surveys incorporated in my early secondary science classes for potential questions. Appendix S displays Sage's final survey as printed and distributed to students on the first day of science class; this particular sample also includes hand-written student responses of a year 10 non-Māori female.

Improving variety and choice in process and product. As in the first collaborative planning session, teachers worked to implement greater variety and choice in process and product. Teachers chose to assess student knowledge and understanding through a variety of products throughout the unit rather than the previously more common cumulative written assessment at the end of the unit. For example, teachers discussed the potential of developing and incorporating:

- student choice for body system/disease in an individual student research project;
- variety for student presentations (e.g., Glogster, brochure);
- an investigative assessment involving heart rate and exercise or blood sugar during the circulatory system unit;
- opportunities for learners to verbally explain and video the heart dissection as a small group rather than a written quiz on heart structure and function and
- use of hands-on, first aid “acting out scenarios” to assess student ability to respond to health emergencies appropriately applying ‘human body systems’ scientific knowledge.

Transitioning from collaborative planning to classroom action. Alton, Sage and Turin agreed to follow-up the second planning session with continued individual and collective planning at both the big picture unit level (transferring the brainstorming session onto the school’s science unit template) and lesson level (typing out the specifics of the introductory survey) with research support from me. To facilitate pro-active communication with whānau participants, I also created and distributed to whānau participants a summary of MMAR research activities and findings to date, clarifying the research-based decisions behind teachers’ development and implementation of differentiated human body systems unit plan in the *Acting* phase (see Appendix T). The next section of this chapter explains how teachers collectively and individually implemented the collaboratively-designed plan for differentiation of the science curriculum (research question 4).

Acting

As arranged in the second collaborative planning session, Sage and Turin implemented the collaboratively planned differentiated years 9 and 10 human body unit across four years 9/10 classes in Term 1, 2016 (January-May). All fifty-six year 9 and thirty-five year 10 students participated in the differentiated human body systems ‘Staying Alive’ unit. As previously indicated in this chapter, Alton was allocated a years 7/8 class instead of a year 9/10 class over the summer due to falling enrolment, so he opted to continue in the study by integrating differentiated teaching and learning into his years 7/8 ‘Kitchen Chemistry’ unit instead.

Of the original 39 student research participants, all 32 who remained enrolled at the school in 2016 participated the *Acting* phase. A comparison of participating students’ demographics in the *Acting* and *Reconnaissance* phases is shown in Table 7.4. The overall demographics of the school shifted slightly, impacting the representative nature of the student research sample by culture and gender. While the school saw an overall increase in Māori representation in years 7-13 (49% to 56%) and within the year 9/10 cohort (45% to 55%), the transfer of 4 Māori and 3 non-Māori participants to other schools meant my Māori research participation dropped from 38% to 34% and the non-Māori percentage rose from 62% to 66%.

Because 6 of the 7 students who left were female, male representation among my research population increased from 35% to 41% and female representation decreased from 64% to 59%.

Table 7.4: Comparison of *Reconnaissance* and *Acting* Participating Students' Demographics

Demographic Information	Māori	Non-Māori	Male	Female
Reconnaissance Participants (*n* = 39)	38%	62%	36%	64%
Acting Participants (*n* = 32)	34%	66%	41%	59%
Reconnaissance Year 9/10 Cohort (*n* = 88)	45%	55%	55%	45%
Acting Year 9/10 Cohort (*n* = 91)	55%	45%	58%	42%
Reconnaissance School Population (*n* = 344)	49%	51%	50%	50%
Acting School Population (*n* = 264)	56%	44%	53%	47%

Data collection and analysis. Teachers' implementation of differentiated units occurred over 11 weeks during the first school term of 2016. During the implementation phase, I conducted nine separate classroom observations on days selected by Alton, Sage and Turin. The teachers, lesson topics and primary mode of instruction observed are displayed in Table 7.5.

Table 7.5: Classroom Observations Conducted During the *Acting* Phase

Teacher	Lesson Topic	Primary mode of instruction
Alton	• Acids and Bases Neutralisation • Fermentation	- Student (hands-on) investigation - End of unit, student (hands-on) investigative assessment
Sage	• Introduction to Year 9/10 science • Exercise and pulse rate • Human body systems	- Pre-assessment survey; lecture/discussion on expectations - Student (hands-on) investigation - End-of-unit, written, student assessment
Turin	• Proper microscope technique to view cells • Proper microscope technique to prepare and view onion cells	- Student practical (hands-on) activity - Student practical (hands-on) activity

Procedures for gathering *Acting* qualitative classroom observations and teacher interviews adhered to the framework previously established in Chapter 6 when I discussed methods for *Reconnaissance* teachers' qualitative data collection, analysis and integration. As in the *Reconnaissance* phase, each *Acting* lesson observation consisted of a full one-hour class session. One-on-one, debrief interviews with teachers occurred, whenever feasible, directly following classroom observations. This influenced the nomination of lessons for observation as, when possible, teachers scheduled classroom observations that could be easily followed by a teacher non-contact period or lunch/morning tea for debriefing.

My goal was to collect data at various stages in the differentiated teaching and learning implementation process. Therefore, lessons observed ranged from pre-assessment interest inventories on the first day of school (Sage, introduction to year 9/10 science lesson) and hands-on mid-unit laboratory partner work (Turin, microscope investigation), to end of term individual and group assessments (Alton and Sage). My 'hands-on' dissection observation of Turin was disrupted by intermittent access to water on school grounds. Due to time constraints, Turin chose to cancel rather than reschedule the dissection, moving on to other curricula topics instead. In addition to information gathered on classroom observation templates and interview field notes, other collected *Acting* phase data included: digital and photocopied teacher unit and lesson planning documents, digital and printed copies of student hand-outs, photographs of teacher whiteboard notes, as well as scanned exemplars of students' exercise books, projects, and assessments.

All descriptive data were collected, analysed and integrated in accordance to qualitative data collection procedures introduced in Chapter 6. *Acting* findings were then used to develop the implementation section of this chapter as well as the *Evaluating* findings of Chapter 8. Findings and examples that revealed how teachers, from their perspectives, differentiated the science curriculum to improve (a) content relevance, (b) assessment and accommodation of student readiness and (b) variety and choice in process and product are presented and explained in the next section of this chapter. Evidence and analysis of the impact of teachers' differentiation on student learning – from the perspectives of teachers, students and whānau – is presented in the subsequent *Evaluating* chapter.

Implementation of the differentiated science unit. Sage's revised body systems 'Staying Alive' unit plan created in response to the second collaborative planning session (Appendix U) addressed all differentiated teaching targets. Classroom observations and teachers' daily lesson planning similarly provided evidence that each teacher incorporated differentiation for each of the differentiated targets at least once, but typically, several times throughout the term.

Relevance. Teachers made an effort to teach only topics and facilitate activities that they deemed relevant to students' current or future lives in and/or out of school during the MMAR *Acting* phase. Sage reflected that relevance became her differentiated focus of the term, "I tried to make it [student learning] heaps more relevant than years before" (teacher discussion). Strategies Sage employed to promote relevance included: (a) linking body systems to potential injuries or diseases that students and their whānau might have and how to treat them (b) incorporating local or national examples (visit to or from gym instructor, Pilates or sports coach) and (c) connecting learning to current national or international events such Zika and its potential effect on Olympic competitors (teacher unit and daily lesson plans).

Alton reported the applicability to future NCEA studies greatly impacted the content and processes he selected as relevant to students for his classroom. As such, he worked to grow students' current abilities to confidently and capably conduct investigations extending their ability to observe, hypothesise, plan and evaluate. Expected secondary laboratory behaviours and etiquette as well as competence in science content and communication skills were modelled by Alton as he sought to develop science capabilities (Ministry of Education, 2007, 2015b) in early secondary science students. Relevance drove Alton to teach chemistry basics (chemical reactions like neutralisation) in a kitchen chemistry context (teacher unit plan and classroom observations).

Turin reflected that relevance for him was more than content selection but a wider approach to teaching focusing on:

> Just trying to bring it back to them and just be positive to them. They're just kids. And it's science; they're not going to remember any of this in 5 years' time. But hopefully they might remember how to think and they'll remember I had a good experience in science . . . . It's the whole whanaungatanga thing (Turin, individual teacher interview).

Assessment and accommodation of student readiness. Both Sage and Turin began the term with Sage's prior-knowledge and interest individual student survey. In the first two weeks, the science department also administered the New Zealand Council for Educational Research (NZCER) standardised *Science: Thinking with Evidence Test* (2016). Turin reflected in an interview that such tools had the potential to be helpful pre-assessment tools to gauge where students were at but warned against overestimating their value,

> They're nice [but] they're not the be all and end all. I think they give you a kind of an idea but I don't think they are completely relevant 'cause . . . Matty he got 5 and he's obviously more than a 5, he just couldn't be bothered. And then . . . one kid in 7/8 who is very, very bright and maybe got 1 or 2 wrong. I was like, wow this guy's a genius! But you talk to him and he has trouble communicating . . . I think they're a nice indicator at this time of the year . . . Couple of highs. Unfortunately, more leaning toward the low side. More interesting to see how it works at the end of the year when we retake it.

Turin was dismayed that, unlike his previous school, no standard existed for formative pre-assessment of student knowledge of unit content and skills. Therefore, Turin implemented his own strategies throughout the unit to gauge student understanding, including "drawing [what they'd learnt so far] . . . . pop quizzes as well" and practical skills assessments. He explained,

> I got them to do a measurement lab last week, I think you do that with 7s and 8s, set up about 5 stations and watching them as they go around to see who does what. I put out the triple beam as well. I think one person got that . . . . Yeah, I do things like that just to see how they're going (individual teacher interview).

Differentiating to meet the needs of students across the learning spectrum was expressed as a high priority for teachers in the *Acting* phase. Although written lesson plans implied little variation for ability between classes, teacher and individual interviews and classroom observations revealed variation in the level of depth and complexity of parallel topics covered in response to class and individual students' needs.

Alton reflected that as a result of participating in the MMAR study he was more conscious of his differentiation in response to student differences in ability within the junior science classroom,

> Just that on the [learning] spectrum . . . . I [now] tend to it differently. I might start with the same core tasks but then how I question or how I approach with Moana [scientifically talented student] would be totally different from how I'm approaching the low-end kids (teacher discussion).

Sage reflected that differentiating to meet the needs of low-ability students was critical "'cause otherwise they feel they can never achieve . . . I think they would always fail everything and [it would] put them off science probably" (teacher discussion). Sage described modifying assessments for a low-literacy student during the term, allowing him to "just do his posters in pictures seemed to work and he got the idea" (teacher discussion). Sage described how when working through a pulse rate worksheet on the heart, the "smarter kids did that by themselves. The other[s] . . . I went through and helped them more" (individual interview). Scaffolding for students with low-literacy skills through 'fill-in-the-blank' typed handouts or experiment templates (in place of the lecture-style, note-copying from the board discussed in *Reconnaissance* focus groups) was observed in all classrooms.

Alton expressed similar urgency for differentiating the curriculum for scientifically talented students, "otherwise they'll just get bored and stagnate" (teacher discussion). Sage described how she [typically] had extra work ready for the scientifically talented students who might work at a faster pace than their peers, "like these [papers] I have been carrying around for the last week . . . if we have time to do them then I'll do them" (individual interview). Alton and Turin tended to differentiate by challenging talented students through spontaneous interactions – probing and questioning students' understanding and application skills during investigative activities, rather than setting up alternative assignments or products (classroom observations).

Variety and choice in process and product. Alton, Sage and Turin each incorporated process variety into their science classroom teaching and learning during the *Acting* phase (teacher planning and classroom observations). All teachers utilised hands-on, practical work in response to student and whānau requests for less emphasis on lecture and note-oriented lessons. When reflecting on the differentiated strategy that he felt he implemented most effectively, Alton declared "for me . . . it would be the practical" (Alton, teacher discussion). Examples of hands-on student learning included: microscope cell investigations (Turin), heart and lung dissections (Sage), yeast and sugar investigations (Alton) and ginger beer fermentation (Alton).

Teachers also incorporated differentiation by variety and choice for assessment as evidenced in the student disease research project (Sage; see Appendices V & W) and smoking posters (Turin). In addition, I observed Sage facilitating an exercise and pulse practical to assess students' investigative and graphing skills (see Appendix X).

The paradox of planning and spontaneity in attaining deferential differentiation. All teachers identified the importance of both having a plan, such as the unit overview created by Sage (Appendix U) with clear learning objectives to guide the unit, but emphasised the value of flexibility and modification in response to student need. "It's nice to have a plan to go in with and then you usually go off it anyway" (Sage, teacher discussion). Alton likewise agreed that a plan was essential but should not restrict teacher responsivity to student needs that become apparent on a daily basis within the classroom. He advised planning for differentiation should be used

> for [a] starting point and ultimately [still allow us to] change things. Ahhh. I'll [try] it that way, that might work better. I guess for me I quite like[d] that with the [differentiated unit]. Oh yeah, I'll try that, I'll try that. I'll do it that way . . . . I've used most of [my plan] but I certainly haven't done it in that order and in the same way [as planned] (teacher discussion).

In his individual interview, Turin expressed similar sentiments regarding the planning and flexibility conundrum, describing how he had shifted his approach to teaching throughout the years from specific, focused daily learning objectives to broader unit learning outcomes to foster a more responsive learning environment,

> I went through a stage where I put up the learning objective for that day, for that lesson. And I was going... AAAHHH!!! 'Cause often I wouldn't achieve that objective because I would change tack [to accommodate student readiness], so now I follow the learning outcomes. There's [only] a dozen of them. I'm satisfied with that but I don't know if that's good.

All three teachers took longer to teach their units than originally intended during the summer planning session, with Alton and Sage continuing the unit into term 2. Turin reflected on the reasoning for such changes,

> I go slow 'cause I want to make sure [students are learning]. You know what it's like. I'm not rushing this 'cause I thought okay, today I'd do the onion, except in my last class, it was like you have no idea what you are doing, eh? We'll do it tomorrow (individual interview).

Turin, like Alton and Sage, prioritised modifications of differentiated curriculum knowledge and skills in response to monitoring of student readiness over rigid adherence to the pre-determined unit overview and implementation timetable.

Summary

This chapter introduced the key meta-inferences derived from the integration of *Reconnaissance* quantitative and qualitative data collection and analysis. It then explained how I shared these findings with teachers, emphasising the differentiation areas identified by students and whānau as having the most potential for meeting existing science students' needs. A description followed detailing teachers' process of selecting and planning for differentiation targets. I then explained how teachers, from their perspectives, implemented the differentiated science curriculum in their classrooms. Evidence and analysis of the impact of the differentiated curriculum on student learning – from the perspectives of teachers, students and whānau – are presented next in Chapter 8, *Evaluating*.

Chapter 8:
Evaluating

Kohia te kai rangatira, ruia te taitea.

Scatter the sapwood, gather up the chiefly food; seek perfection.

This chapter focuses on the methods and findings of phase 5 – *Evaluating*. I report on stakeholder perceptions of the effectiveness of teachers' implementation of a differentiated science unit designed in response to community input and teachers' aims of improved:

- content relevance, with a focus on connections and applications to students' 'real lives' outside of school;
- assessment and accommodation of student readiness and
- variety and choice of process and product, with an emphasis on more hands-on learning.

I also discuss other differentiated teaching and learning themes that emerged in the *Evaluating* phase including communication, classroom management and the influence of individual teachers in meeting learners' needs. The chapter then transitions into a discussion of the 6 key meta-inferences derived from integrating my *Evaluating* quantitative and qualitative findings. A brief description of teachers' on-going *Monitoring* (phase 6) in response to these findings is included. The synthesis of my research findings across all 6 MMAR phases, including situating them within the literature on inclusive education and differentiated instruction, is presented and discussed in Chapter 9.

Evaluating

The purpose of the *Evaluating* phase was to assess the impact that teachers' responsive differentiation had on student learning. In so doing, I sought to answer research question 5, 'How does differentiation of the science curriculum impact student learning?" I approached data collection and analysis in the *Evaluating* phase from the explanatory sequential mixed methods approach (QUAN followed by QUAL) also utilised in the *Reconnaissance* phase (Chapters 5 and 6). However, as Figure 8.1 illustrates, I needed to adjust the traditional sequential QUAN $\rightarrow$ QUAL model to incorporate concurrent *Acting* observations of teachers' implementation of the differentiated unit as well as student mid-unit input on responsive science teaching and learning.

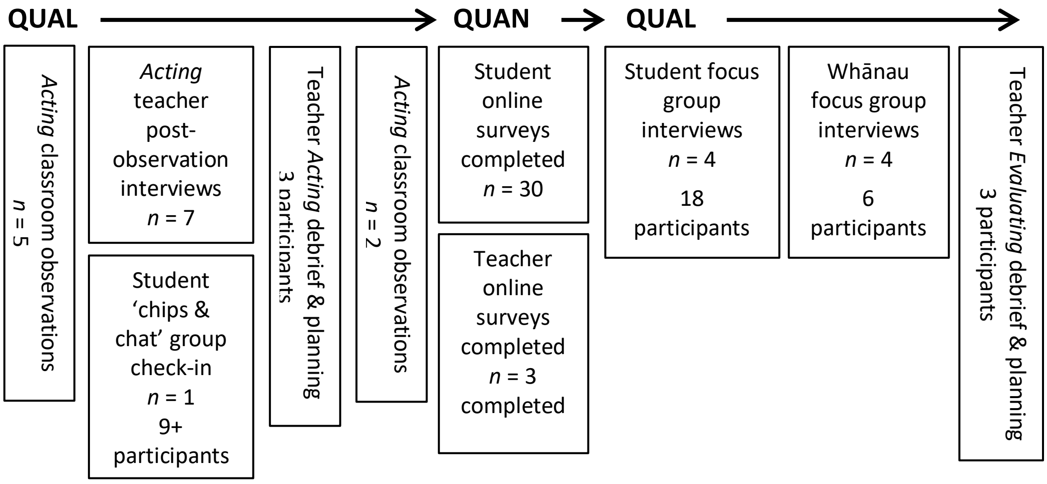


Figure 8.1: Mixed methods data collection used to evaluate the impact that teachers' differentiated unit had on students' learning.

Adjusting my research design in response to changes in the school environment aligned with recommendations of Venkatesh, Brown, and Sullivan (2016) that mixed methods researchers should be flexible in their approach to mixed-methods to ensure they use the design that best suits their needs and fully answers the study's research questions. A more detailed description of the data collection and analysis methods follows in the next section of this chapter.

Data collection and analysis. Table 8.1 presents an overview of my quantitative and qualitative data collection methods as well as a comparison of pre/post participant involvement. *Acting* classroom observations and teacher individual and group interviews discussed previously in Chapter 7 were also utilised in the evaluation process.

Table 8.1: Comparison of Participant Numbers in *Evaluating* and *Reconnaissance* Phases Arranged by Data Collection Tool

***Evaluating* data collection format**	***Reconnaissance* Participants**	***Evaluating* Participants**
Teacher QUAN survey	*n* = 3	*n* = 3
Year 9 student QUAN survey	26	20
Year 10 QUAN survey	13	12
Teacher QUAL interviews and/or focus groups	3	3
Year 9 QUAL focus group	13	8
Year 10 QUAL focus group	14	10
Whānau QUAL focus group	7	6

***Quantitative*.** I collected quantitative student and teacher feedback via revised online differentiated teaching and learning surveys (see Appendices I-K) at the end of the *Acting* phase, after teachers and students had completed the differentiated unit (May-June, 2016). In addition to the previously used *Reconnaissance* survey questions, new questions probed how teachers had responded to student input and the impact that teachers' differentiation had on student learning. Examples of additional student survey questions are included in Figure 8.2 (Appendix K provides the full list of added questions). Teacher surveys included one additional background qualitative question: "How has being involved in this research influenced what/how you teach in the classroom?" (see Appendix K).

What is your 2016 science learning experience like when compared to previous years?

- I am learning heaps more!
- I think I am learning a bit more this year.
- I don't think I am learning any more or less than before.
- I think I am learning less this year.
- I am learning much less than in previous years.

Over the summer, the science teachers reviewed summaries of your responses to the previous online survey. Do you feel your responses have been used by teachers to improve what and how you learn in your science classes in 2016?

- Definitely!
- Yes, I think some of my responses have been used by teachers to improve how we learn.
- Maybe? Not sure.
- Not really.
- Definitely not! I feel like my responses have been ignored and we have the same issues as last year!

  Please explain (optional).

Figure 8.2: Excerpts from student *Evaluating* survey questions probing students' perspectives on the impact of teachers' differentiation on student learning.

As in the *Reconnaissance* phase, I exported survey responses from Survey Monkey into SPSS for statistical mean analysis. I then prepared my quantitative data by incorporating *Reconnaissance* coding and scaling processes for participant science attitude, importance and usage ratings. Using identical codes and scales for both *Reconnaissance* and *Evaluating* data analysis enabled me to determine changes in teacher and student perceptions of differentiated science teaching and learning – and teachers' effectiveness in meeting students' needs.

Changes in staffing and teachers' responsibilities, in response to decreased student enrolment, influenced how I analysed the data. Casper's shift to the mathematics department and the hiring of Turin meant I could longer compare changes in teachers' collective perspectives over time. Alton's timetable changes (no longer teaching years 9/10), the integration of years 9 and 10 classes and a shift in assessment structure away from reliance on an end of unit formal test, also meant it was no longer feasible for me to compare student assessment achievement data. Therefore, shifts in teacher viewpoints reported in this chapter emphasise individual change; changes in student learning stem from teacher, student and whānau perceptions of student learning rather than quantifiable pre/post assessment measures.

When analysing the survey responses, I examined similarities in and differences between teacher and student perceptions of teachers' differentiation during the *Acting* phase. Changes in stakeholders' perspectives of value and/or usage of differentiated science teaching and learning strategies were also explored. Careful examination of all survey responses linked to teachers' differentiation aims of improving (a) content relevance, (b) assessment and accommodation of student readiness and (c) variety of process and product occurred.

Paired-samples t-tests were conducted to compare student perceptions of the value in and use of science classroom differentiation strategies before and after the teachers' implemented differentiated human body unit. These tests did not yield any statistically significant results. The lack of statistically significant changes in student perceptions on matched pair pre/post survey responses addressing teachers' goals of relevance, readiness and variety is potentially a limitation of my study. However, the quantitative shifts (or lack thereof) in participant perspectives still provided me with an awareness of topics and direction needed for my qualitative data collection strategies and analysis, particularly when examined in conjunction with frequency analysis (which, unlike the mean comparisons, did not exclude 'unsure' responses for usage) revealing several changes in participant perspective (see Appendix L). Qualitative questions for teacher individual interviews, as well as student and whānau focus group question schedules derived from quantitative analysis, are explained in the next section of this chapter.

Qualitative. As with quantitative data, I focused my qualitative data collection and analysis on findings most linked to teachers' differentiated goals. Classroom observations, teacher discussions, teacher individual interviews, and student and whānau focus group interviews were all used to collect participant perspectives of the impact of teachers' differentiation on student learning.

Observation templates and interview guides (see Appendices Y & Z) were primarily composed of *Reconnaissance* questions (see Appendices N-P) to facilitate pre/post examination. However, additional questions stemming from (a) teachers' differentiated goals, (b) the human body systems differentiated unit content, processes and product and (c) *Evaluating* survey quantitative or qualitative responses were also included in the focus group discussions to enable me to probe student and whānau perceptions. Examples of new student interview questions asked were:

- How have your science teachers increased the relevance of what they teach (content)?
- Why did you "like the body systems" topic?
- Please explain what motivated you to select your topic for the individual research project.
- How do you suggest teachers incorporate "more fun and challenging things to do?"

Sample whānau focus group questions similarly modified included:

- Please describe any changes (good and/or bad) to your [child's] science experience that you have noticed since we last met in December.
- Do you feel that your child is learning more/the same/less in 2016 science classes when compared to previous years? Explain.
- Do you feel your child is being challenged more/the same/less in 2016 science classes when compared to previous years? Explain.

Although improved communication was not selected as a teacher differentiation goal, I chose to include it as a topic in the whānau focus group questions because of its importance, as expressed by whānau, in the *Reconnaissance* phase. I wanted to explore if there were any changes to communication that may have resulted from the differentiation planned and implemented by the teachers.

I used descriptive thematic analysis to make sense of and integrate the large amount of spoken and written data collected on differentiated teaching and learning through qualitative classroom observations and teacher, student and whānau interviews. I conducted constant comparison analysis across the datasets, allowing new codes to emerge in addition to those established in previous phases. Pertinence to the study was determined by:

- recurrence of topic,
- emphasis of topic within or between stakeholder groups,
- convergence with or divergence from *Evaluating* quantitative findings and
- support of or contradiction to *Reconnaissance* meta-inferences.

Integrated quantitative and qualitative findings relevant to my MMAR investigation are shared in the next sections of this chapter.

Findings. All integrated quantitative and qualitative findings discussed in this chapter are grouped and presented thematically. The results linked to teachers' differentiated goals of relevance, assessment and accommodation of student readiness and variety of process and product are explained first. Other prominent themes are detailed next, followed by the *Evaluating* meta-inferences.

Relevance. Participating teachers aimed to increase content relevance and their post-surveys indicated that they had all done so, "intentionally and often". As such, teachers were surprised to find that overall student quantitative and qualitative responses indicated little shift in perceived relevance. "That's interesting because I would have thought it would have been more relevant" (Sage, teacher discussion).

Figure 8.3 shows the slight changes that occurred in pre/post students' perceptions of science content relevance. Using an attitude scale of 0-2, with 0 – Disagree; 1 – Not sure; 2 – Agree, student reported still being 'unsure' of the relevance of science to their lives (pre/post M = 1.38, 1.39) and culture (pre/post M = 0.93, 0.96). Student perceptions of the science relevance to whānau actually decreased (pre/post M = 0.89, 0.75). A slight change was also observed in student mean responses for teachers' usage of and ability to link science teaching and learning processes to everyday life (M = 3.32, 3.36). Students did identify, however, noticeable improvement in product relevance with better use of assessment that explored real science problems (pre/post M = 2.28, 2.75) and challenged students to connect their ideas to current and historical scientific knowledge (pre/post M = 2.65, 2.82).

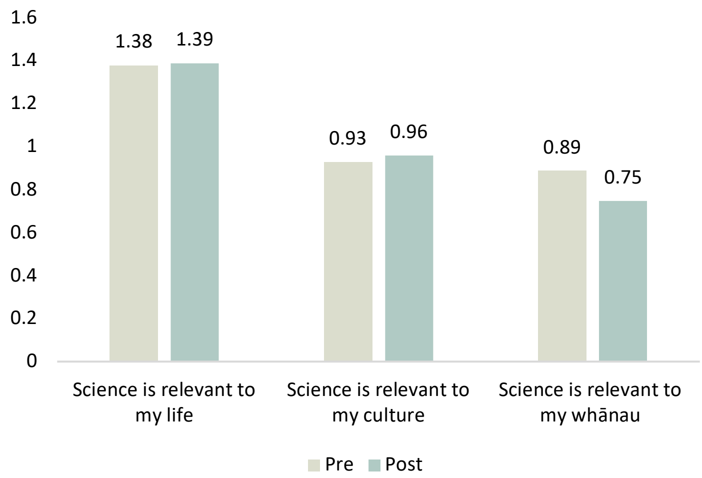


Figure 8.3: Contrast in pre/post mean student survey responses regarding science relevance.

Despite little shift in student perceptions of science relevance on the survey, student focus group responses were typically positive. Perceptions varied from "we are learning about more stuff that is relevant" (year 9 non-Māori female) to "it's probably about the same [as last year]" (year 9 non-Māori male). Indeed, most students and their whānau members, particularly those identified as scientifically talented, agreed with teachers that the differentiated human body topic had more relevance than topics in previous years, reflecting,

> With diseases and stuff, it could be relevant to family members and things like that or if someone had like broken a bone . . . because you had done science and broken bones, you could tell the ambulance persons (year 9 talented Māori female, student focus group).

When student focus group participants were asked why teachers' efforts to increase relevance were not viewed positively, students hypothesised, "Because what's real to them might not be what is real to us" (year 10 Māori female). The most vocal complaint over content relevance came from a year 10 non-Māori male with dyslexia and dysgraphia who wished for greater connections between what was learnt in the classroom to the local farming community,

> One thing that I don't like about science [this year] is the stuff that we're learning . . . I sorta want to learn . . . more towards ag science . . because at the moment I've got a job and I'm working for a bull breeder in . . . He does the whole genetic modifying of his cattle and stuff . . .. . . Last year – you guys remember – I was like a complete dickhead . . . Since I've been working with [the bull breeder] I'm like completely different (focus group).

Whānau participants praised teachers' efforts to increase relevance and described the differentiated human body unit as "better subject matter" (mother, year 9 non-Māori male). The father of two year 9 non-Māori females reflected,

> Through the body systems, both of them [daughters] were quite forward about bringing – initiating discussion on the science they were having. . . . we were getting good feedback about it . . . discussion about skeletons and things like that when we're out and about. So that was certainly a good unit and they responded to it well.

The mother of a scientifically talented year 9 non-Māori male similarly reported that after the differentiated unit her son now had "a better understanding of science as a whole that it impacts on every area of the natural world and the methods of cause and effect as well as the correct terms and names of materials."

Whānau were not concerned by the lack of positive change in students' perceptions; in fact, whānau actually shifted away from their earlier *Reconnaissance* views on the high importance of teachers selecting content connected to students' interests. The mother of a year 10 non-Māori male with learning difficulties summarised the focus group's new stance,

> I don't think science has a lot of relevance when you're 12 or 13 but when you are older you think, 'Oh, I did learn that!' So [we] think you should ignore the children. 'Cause . . . You don't know what you're going to do . . . I liked biology - but I didn't particularly like physics, but I ended up doing so much physics that it wasn't funny. And I thought, 'Oh, I know this!' but I . . . couldn't have cared less when I was 15, 16 or so. I think yeah, ignore the children.

Other whānau focus group participants agreed, stating, "They don't know what is relevant. What's going to be relevant to what?" (mother, talented year 10 Māori male) and "I want it to be relevant whether they think it is relevant or not" (father, two year 9 non-Māori females). He further elaborated,

> Research tells us that our kids are going to have 27 different careers in their lifetime or some ridiculous figure like that. Whereas our generation you only had one or two. So, they've got no idea what's going to be relevant in their life later on.

Due to the ambiguous nature of relevance, whānau observed that learners and their whānau relied on teachers' professional discernment for determining the junior science curriculum most applicable to students' upper secondary schooling and potential career needs. The father of two year 9 non-Māori females admitted this was difficult for him, "I guess I have to say there is [a need for trust in teacher competence] but my natural instinct is I don't trust teachers. Sorry!"

Whānau emphasised the importance of students gaining competence in both concepts (knowledge) and skills (methods). "I think we need to be teaching our children how to think. Rather than how to know, teach them how to think" explaining, "what is relevant in my mind is making them able to think, take in information, analyse it and come out with a problem or a solution (father, two year 9 non-Māori females). The mother of a talented year 10 Māori male voiced, however, that "you've still got to have a basic knowledge" stating that she would be satisfied as long as "the core areas of science are all gone through [so] they can at least experience it themselves. Physics for example. I thought that would be horrible but it's actually quite interesting. I might take it further."

When asked if a more explicit connection between science content and skills to students' current or future lives could have a positive effect on students' perceptions of science relevance, whānau replied,

> I think maybe you might be right for today's kids. Back in my day that's what you learnt and you learnt it because that was what was being taught. It wasn't until your senior years or you'd left school that you actually did learn that it was relevant. But perhaps today's kids are a bit different (father, two year 9 non-Māori females).

Teachers similarly debated the meaning and applicability of relevance for differentiated science teaching and learning. Alton reflected,

> The expectation of relevance maybe shouldn't always be there . . . It's been nagging in my head about whether or not we should . . . I remember doing body systems at school and it was just interesting because it was about me, how it works. It's something that's just inherently interesting.

Teachers, like whānau focus group members, felt that most things could be argued to be potentially relevant in today's unpredictable world. However, Alton also felt the opposite was true, that you could also credibly argue that most things might be potentially irrelevant, explaining, "It's almost like if you know how to cook in life. Might not be [relevant]. You could get someone else to cook you dinner. Does that make sense?" He argued that science relevance should be defined as "having an application" and that included "teaching for physics and chemistry and biology to enable kids to have the background to take it further" at secondary and post-secondary levels (teacher discussion). However, both Alton and a student focus group participant independently concluded that relevance could actually restrict learning, arguing that sometimes content is not "really [practical to life] but it's fascinating!" (year 9 non-Māori female).

In summary, participating teachers, students and whānau continued to affirm the importance of science teachers teaching relevant science knowledge and skills throughout the *Evaluating* phase. However, participants' perspectives on the definition of relevance and how to best determine relevance varied greatly, with some teachers arguing that any topic or skill could be viewed as relevant or irrelevant depending on how you approach it. Little change in student perspective on the relevance of science to life was observed despite teachers' emphasis on relevance in the *Acting* phase and whānau reports of teacher improvement in this area. This led teachers and whānau to question whether or not students were capable of predicting what might be relevant to their future lives or not.

The next section of this thesis explores the response to teachers' differentiation for assessment and accommodation of student readiness. Teachers, students and whānau alike observed improved ability for teachers to meet students' needs through the changes teachers made in using this strategy. However, as with the differentiation for relevance just described, participants noted areas of assessment and accommodation of student readiness that still needed improvement, particularly for scientifically talented students, as explained in the next section of this thesis.

Assessment and accommodation of student readiness. As described in Chapter 7, Sage, Turin and Alton also strived to assess and accommodate student readiness throughout the *Acting* phase when they implemented their differentiated units. As Figure 8.4 Illustrates, both Alton and Sage reported shifts in perceptions of their value and use of differentiated assessment to determine and accommodate student readiness. Sage identified an increase in her use of pre- and mid-unit assessment to respond to students' needs. She also cited growth in her ability to differentiate in relation to science students' interests, learning styles and preferences. Sage reflected on her *Evaluating* survey that she now had "more understanding of how students like/prefer to learn" which she believed was important because "if they are enjoying the learning they are more likely to understand and retain the information." While Sage's opinion of the importance of pre-assessment remained 'neutral', her perception of the value of relating teaching and learning to individual student's interests increased to 'important'.

Alton similarly reported an increase in how he valued mid-unit assessment, accommodation of student learning style/preference and support for students with learning difficulties. Alton identified mid-unit assessment and support for students with learning difficulties as two areas he had strengthened during the *Acting* phase. When asked how being involved in this research had influenced what/how he taught in the classroom, Alton reported, "improving my planning to have activities which extend the more able while also giving time to improve engagement of the less able" (open-ended survey response).

Turin's responses were similar to Sage and Alton's with two exceptions. Turin placed greater value on pre-assessment and lower value on incorporation of student interest into his teaching than Sage or Alton. He reported the greatest impact of the research on his teaching had been, "questioning and having conversations with students targeting different ways/angles that the student[s] may achieve the learning outcome for that lesson" (open-ended survey response).

Differentiated Strategy	**Teacher**	***Reconnaissance***		***Evaluating***
Pre-assess readiness to adjust unit	Sage	Hardly ever	→	Sometimes
Assess student understanding throughout unit and modify teaching accordingly	Sage	Sometimes	→	Intentionally/often
	Alton	Important	→	Essential
Relate teaching to student interests	Sage	Neutral	→	Important
	Sage	Sometimes	→	Intentionally/often
	Alton	Sometimes	→	Frequently
Incorporate student learning styles or preferences	Sage	Sometimes	→	Frequently
	Alton	Neutral	→	Important
	Alton	Sometimes	→	Frequently
Address learning disabilities to provide students with attainable growth	Alton	Important	→	Essential
	Alton	Sometimes	→	Intentionally/often

Figure 8.4: Teachers' perceptions of importance and usage of differentiated 'readiness' components, *Reconnaissance* and *Evaluating* phases.

Quantitative and qualitative data collected from students and whānau acknowledged teachers' efforts to improve their assessment of and accommodation for student readiness. Figure 8.5 shows positive changes in pre/post mean student responses on *Reconnaissance* and *Evaluating* survey questions appraising teachers' use of differentiation strategies for readiness.

Students reported an increase in teachers' use of pre- and mid-unit assessment and appreciated teachers' willingness to adjust the unit pace and content to meet their needs. A year 10 Māori female focus group participant identified it helpful when Sage,

> does that thing you know where you learned something a few times and then it's stuck in your brain so if you leave it for a little bit longer and then go back to it you remember -- that's what she does. She does not teach us the same thing over and over again so we're just like I don't even want to learn this.

As shown in Figure 8.5 students also identified improvements in teachers' abilities to relate to student interests, challenge students and help students learn new things. Indeed, when asked to rate their learning during the implementation of the differentiated science unit as opposed to the previous year, the majority of students responded they were learning 'heaps more' (45%), or a 'bit more' (48%), with only 7% indicating they were not 'learning any more or less than before'. No students – including those with learning difficulties and those identified as scientifically talented – reported learning less or much less than in previous years. A year 10 non-Māori male focus group participant reflected that his behaviour had also changed in response to the positive changes in instruction, "I'm not as naughty – because we know what we're meant to be doing now." His year 10 Māori female peer agreed, "I understand some things more clearly now."

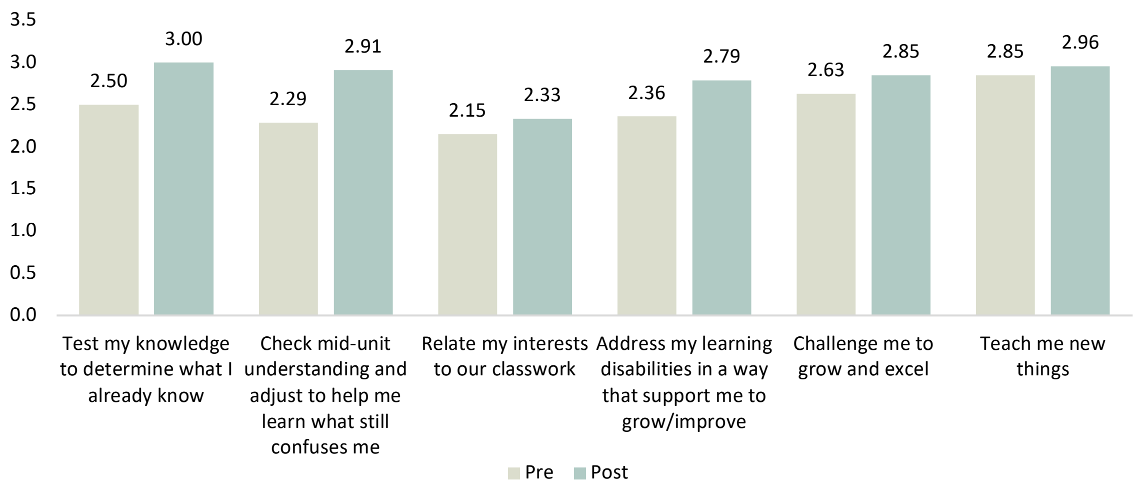


Figure 8.5: Pre and post quantitative survey mean student responses regarding science teachers' use of differentiation in response to student readiness.

Most whānau focus group participants also felt that more learning was occurring under the teachers' differentiated unit. The mother of a scientifically talented year 9 male, when asked if her son was learning more responded, "Yes, yes, yes!", remarking that her son no longer "moan[ed] about [science] class so all good." She especially appreciated Turin's encouragement of her son to "figure out his own answers to problems."

The father of two non-Māori year 9 females in Sage's class similarly reflected, "I think they are learning more this year, my ones anyway . . . from the perspective of challenging their minds, it's good." Most student focus group participants talked of a suitable level of classroom challenge during the *Acting* phase, that increased appropriately in difficulty as the unit progressed, "She challenges us and it gets harder as the time goes on" (year 10 scientifically talented Māori female).

Although all three teachers reported that addressing students' strengths and talents was important and something they frequently did, student responses (M = 2.58) indicated that teachers still needed to improve their awareness of student prior knowledge and individual strengths and talents – especially within the mixed year level classes. Two year 9 Māori females with learning difficulties reflected that they found learning alongside year 10 students especially difficult,

> Because some of them [year 10 students] are at a different level as us and they can move into their work much faster. . . I think it's too hard . . . I get confused really easily. Without Miss saying, explaining it more easily, I don't understand. And then I just give up.

In contrast, other students expressed frustration over a perceived lack of challenge in the differentiated curriculum. A scientifically talented, year 10 non-Māori male focus group participant admitted that he would like the class to be "a bit harder." When his peers looked at him like he was crazy, he explained, "This is for me, not for you. You guys can study at your level and I need to study at my level." The mother of a scientifically talented Māori year 10 reported that her son felt that integration of years 9 and 10 students had lowered the academic challenge by increasing discipline challenges,

> My feedback from [my son] is that he doesn't like the 9 and 10. He would prefer year classes . . . same with his whānau. He finds with his [9/10] science class . . . it takes a long time for the teacher to get them to be quiet so she can speak so that's a lot of waste of down time as far as I'm concerned. And he gets frustrated with some of the behaviours I think.

Students observed that it was particularly difficult for teachers to provide an appropriate level of challenge for learners who possessed both high intelligence and learning difficulties that constrained student ability to share ideas/thoughts. A scientifically talented year 10 non-Māori male reported being "annoyed" that his "dysgraphia and dyslexia" had resulted in him "doing year 9 work. . . I can easily see that it's year 9 [on the worksheets] and she just scribbles out the 9 and puts 10."

Therefore, while most participants perceived teachers' differentiation for assessment and accommodation of student readiness as improving student learning within the classroom, some students and their whānau, particularly rangatahi at the extremes of the learning continuum – students with learning difficulties and exceptional science talent – reported an on-going need for greater adjustments to accommodate individual learner needs.

Variety and choice in process and product. As introduced in Chapter 7, the third differentiated goal that participating teachers set for themselves was increasing variety and choice during the implementation of the differentiated human body unit. Sage reported growth in both value ('important'→ 'essential') and usage ('frequently → 'intentionally and often') of the incorporation of a variety of instruction other than a textbook (teacher survey). While Alton's high value and usage of instructional variety remained consistent ('essential'/'intentionally and often'), his view of the importance of incorporating learners in designing/selecting learning activities shifted from neutral to important (teacher survey). Turin's *Evaluating* ratings for high value and usage of process variety and student choice mirrored Alton's.

The students' survey responses supported the teachers' perceptions that teachers had increased process variety and choice. As Figure 8.6 shows, students reported an increase in several differentiated teaching strategies:

- variety in learning,
- diversity of classroom activity,
- use of multiple supportive tools,
- student choice in designing/selecting activities,
- flexibility in student peer collaborative grouping and
- pacing.

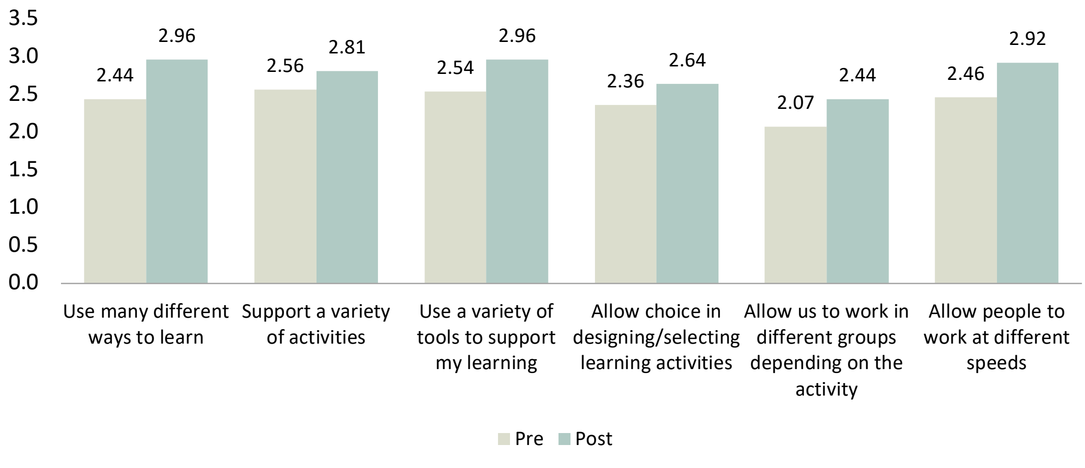


Figure 8.6: Pre/post survey responses: Process variety and choice.

Qualitative data collected from teachers, students and whānau, supported the quantitative findings. Both years 9 and 10 student participants reported positive changes in teaching, with a shift away from lectures:

> Now it's more like a whole variety of things . . . We get like crosswords and wordfinds and stuff. And like fun puzzles . . . We try things out like we cut open a heart and lungs so far. And so, there's like more activities . . . I'm actually taking it in, that's what I mean (year 10 non-Māori female).

Other peers agreed. "To make us learn she's like doing worksheets and like making us write stuff off the board and all like sort of different ways . . . And we did something with the computer room" (year 10 non-Māori female).

Several students and whānau reported that teachers had achieved their goal of meeting students' needs through increased hands-on, practical laboratory work. The father of two non-Māori year 9 females reflected that although his daughters "said they didn't like the dissecting and things like that, I think that they did. They're probably some of the queasy ones. But they talk about it, so it has gone in."

A year 9 non-Māori male student with learning difficulties observed, "Last year we were having more work and just sitting. Less practical – more writing on tests." Examples of practical assessments cited for Sage and/or Turin included: (a) "That thingy we did about the heart rate, when you had to do some exercise" (year 10 Māori female), (b) "like cutting the deer heart and cool stuff" (year 9 non-Māori female), (c) "yeah we blew up lungs" (year 10 non-Māori female), (d) "the microscopes" (year 9 non-Māori male), (e) "the cheek test and onion" (year 10 Māori female) and (f) "magnesium and them – we had to push and let go and turn the Bunsen burner on and it would pop" (year 9 Māori male).

However, other students, often those identified by teachers or whānau as scientifically talented, reported that the incidence of hands-on practical work was lacking. Two year 9 non-Māori scientifically talented males reflected,

- "Yes. There's room for more [hands-on learning]. We've got quite a bit of variety in periods [now] but we don't really have many practicals."
- "[Need] more practical like actually doing! Less wordfinds."

A mother of a mathematically talented year 9 non-Māori male agreed, stating that her son "learns and [is] much happ[ier] if he is doing hands on experiences . . . relevant to [the] science curriculum." She went on to explain that her son remained "frustrated with how science is taught," which, from his perspective, consisted of writing on "human body worksheets" and "no hands-on activity."

Not all students viewed practical activities or assessments as a beneficial component of science teaching and learning; a year 9 Māori female reflected, “I prefer having less practical though.” Others acknowledged that the applicability of hands-on work varied by topic, looking ahead to the next term, “with forces and motion we would be able do a lot more practicals” (year 9 non-Māori scientifically talented male).

The overall student and whānau attitude towards science teaching and learning improved. Students reported on their surveys that they now looked forward to science classes more than in previous years (pre/post M = 1.29/1.57) and that individual science lessons were also more fun (pre/post M = 1.29/1.57). Year 10 Māori and non-Māori females reflected that they were “happy with how it [now] is” because “my teacher is good. involves us has fun making learning fun” (survey, verbatim open-ended responses).

Communication for differentiation. Although students and whānau had identified proactive communication as being of high importance, participating teachers chose not to prioritise communication as a differentiation goal during the *Acting* phase. However, as Figure 8.7 shows, communication was the most common recurring topic discussed by stakeholders (including teachers). Communication was referred to in 85 qualitative responses; the only two other categories with over 50 responses were relevance and hands-on learning.

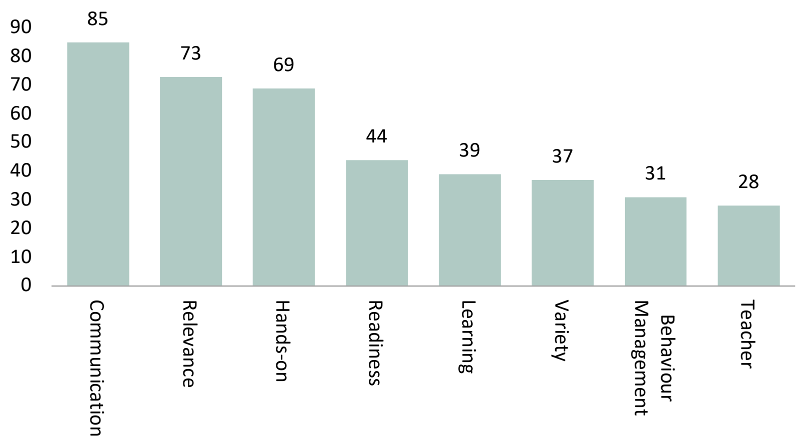


Figure 8.7: Most prominent topics discussed and coded in *Evaluating* participant interviews (*n* = number of references to each particular category).

In this section of the thesis I discuss findings that explain how teachers, as observed by students and whānau, (a) inadvertently made the improvements to communication during the differentiated unit and (b) could have improved the effectiveness of their differentiation through better communication.

How teachers used communication to better respond to learner needs. Participating students from across the learning spectrum reported improvements in how teachers talked to and with learners during the differentiated unit. Students appreciated teachers’ differentiation of spoken instructions with scaffolded vocabulary and supporting visuals such as “drawings” (talented year 10 Māori female) to support verbal instructions and science content. A year 10 Māori female cited “I can understand his language” as a key determining factor to her improved learning in Turin’s class. A year 10 non-Māori male with dysgraphia reported a similar phenomenon in Sage’s class, “We're actually learning something this year. Like I can understand the teacher.” A year 10 Māori female similarly elaborated, “She explains everything like fully . . . she will write it down or she will just tell us exactly off the board, explaining it in a way that we can all understand it.”

Students with dyslexia and dysgraphia particularly appreciated teachers’ differentiation for alternatives to lecture-style notes. “[Last year they] made us write out full sentences . . . She doesn’t . . . She gives you worksheets . . . and you can write the answers . . . instead of writing out the whole part, whole sentence” (year 10 non-Māori male with dyslexia, focus group). A year 9 non-Māori female focus group participant with dyslexia voiced similar sentiments, “He puts everything on the board for us to write. Not like ‘oh, that’s what I'm saying.’”

Students also reported teachers’ willingness to talk with students one-on-one by moving around the classroom as another communication aspect that had improved since the *Reconnaissance* phase. A talented year 10 Māori female observed, “Because sometimes I'm like ‘this I don't understand!!!’ and she comes to talk to me.” A year 10 Māori male with learning difficulties agreed, “[This year] the teacher actually comes and shows you what to do.” Students reported that their learning was also enhanced by differentiating teachers’ openness to student peer collaboration. “You can ask other people [this year besides the teacher] that think too much” (year 10 non-Māori male with learning difficulties).

Improvements in nonverbal communication during the differentiated unit, such as volume and tone of voice, as well body language and movement around the room, were also highlighted. A scientifically talented, year 10 Māori female appreciated that her teacher was, “Quite a calm teacher. She doesn't get mad at just anything . . . Not as harsh, [doesn’t say] ‘Everyone needs to shut up! Don’t say anything! Do your work’” (year 10 Māori female).

Years 9 and 10 Māori and non-Māori focus group students also identified humour as an effective communication tool used by Sage and Turin for establishing a welcoming and engaging learning environment for differentiated teaching, “he’s funny . . . he makes funny jokes!” (year 9 Māori male with learning difficulties). Students appreciated it when teachers admitted their own shortcomings, “She makes it fun, like, funny as. She’s like, oh I can’t even draw the fishies. Crack up AS!!!” (year 10 Māori male with dyslexia).

How teachers could better use communication to increase their ability to differentiate for learner needs. Despite the positive improvements reported by students regarding classroom communication, whānau focus group participants remained adamant that how the school communicated with the community hindered teachers' efforts to differentiate to create a responsive learning environment that met individual student needs. The mother of a talented year 10 Māori male observed, "We're only getting -- what we can glean from our children. We don't have any contact whatsoever with the actual [science] teachers." Like many whānau, the mother of a year 9 talented non-Māori male stated that throughout the differentiated unit, she received,

> Better fuller replies to a query into lessons at school from [son's name] but none from the school. It would be nice to have prior knowledge of the topics of lessons to come in order to talk about them at home and help with further information for him.

Whānau reflected that the absence of communication from the school made it difficult for them to analyse the differentiated actions taken by science teachers, "I'm not saying it hasn't been done . . . Our vagueness suggests that is has not been relayed very well" (father of two year 9 non-Māori females).

How communication with the community could increase student perceptions of relevance. Whānau insisted that better communication between teachers and the community was needed to increase their capacity as whānau to support their children's learning, both at school and home. Whānau participants emphasised that they could play a key role in increasing students' perceptions of science relevance if whānau knew in advance what topics were to be covered.

Whānau emphasised the need for more advance notice of all upcoming school events. The father of two year 9 non-Māori females reflected, "Typical[ly] we often don't hear about these things until less than a week beforehand." He explained that if he knew more ahead of time what was happening at school,

> I would enjoy it because then I can bring up the subject and not just talk about science class but bring up the subject to talk about. Yeah if we happen to be out somewhere and see something that links to it like the Hamilton Zoo, if we get to a garden, it would be a great time to discuss . . .

The mother of a talented year 10 Māori male described how she and other farmers could support teachers in providing relevant hands-on learning connections to the community,

> If there was communication with the home, some of us that are farmers . . . we can provide if we know we are having an animal home kill done. Like we have pigs, sheep, cows, whatever! If they want that kind of thing kept and frozen so that there is a supply . . . . or parents might work in the forestry and they might be able to access different things.

The mother of a year 10 non-Māori male with learning difficulties offered to come in and talk to students about how learning physics (something she had hated at the time) had later positively impacted her career choice as a radiographer, “Yeah I don't mind [coming to talk], I don’t ever mind doing that because it's all second nature now . . . It wouldn't be hard.”

How better school-home communication could help teachers respond to individual learners’ needs. Whānau reiterated that as in the *Reconnaissance* phase, poor communication was an overall school issue, not strictly a problem with the science department. “I know you're still focusing on science but the communication across the whole school to the community is very poor” (father of two year 9 non-Māori females), making it difficult to know how to challenge or support their children’s learning. He explained, while other parents nodded their heads in agreement, “It's not necessarily important for us to know in amount of detail what they are learning but I think it's important to know how well they learn”.

Whānau suggested there was little need for science teachers to create new forms of communication to share what and how well students were learning. They thought it would be most efficient for school leadership and teachers to use existing fora such as newsletters, websites and the online grading system (KAMAR) more consistently. The mother of a year 10 Māori talented male cited her frustration over several failed attempts to determine the school’s perspective of her son’s reported decreased levels of challenge and learning in science during the differentiated unit,

> Haven't had any reports or parent interviews or anything. Even the newsletters. We haven't had one all term . . . I've done go on to the KAMAR. Science isn't even on there. There’s been English, maths and social studies . . . I don't expect every single test result to go on there . . . But there is nothing there for science yet all year!

Whānau also expressed the importance of differentiating how and what teachers communicated to the community in response to diverse whānau experience and need. In a conversation highlighting whānau confusion over what they needed to do to support their children in the upcoming transition to NCEA, the father of two year 9 non-Māori females reflected,

> There are a lot of parents that didn't go far in education themselves and [if] they [did], they probably weren't NCEA. They were probably the old system like us . . . They want the best for their kids but they are probably a bit lost about it all too. They're probably more lost about it than we are (father, two year 9 non-Māori females).

Māori and non-Māori whānau alike valued the opportunity to establish relationships with individual teachers, meeting face-to face [Smith’s (1999), he kanohi kitea] to discuss their children’s learning environment and progress within it. The father of two year 9 non-Māori females observed,

> I'm sorry but the house teacher has an overview of the student through the subjects but they don't have that intimate knowledge of the student in that particular subject . . . I prefer a meeting time [with individual subject teachers]. Otherwise you go there and you want to talk to that teacher but now it's time to go home and you haven’t.

Just as whānau asserted “knowing students” (father, two year 9 non-Māori females) as essential to responsive teaching, whānau also stated an effective differentiated community of learning should provide whānau the opportunity to get to know the teachers’ “interests and all that” (mother, year 10 talented Māori male). The mother of a year 10 non-Māori male reported, “I thought it was quite nice when there was a couple of newsletters last year that introduced [the new teacher], had a bit about Kyliah and what she did.” Despite being an alumnus of the school and on the board of trustees, the father of two year 9 non-Māori females reflected that he, too, needed opportunities to know teachers better, “There are teachers who have been here since [my year 11 son] started that I still . . . haven’t met.”

Sage’s frustration, expressed in an individual interview describing the challenges of differentiating to meet individual students’ needs, supports the importance whānau placed in whānau knowing and connecting with teachers’ individual interests. The lack of community interest in a local competition Sage and her equestrian students had recently hosted led her to reflect,

> No one, not one teacher or management from the school showed up, except the students and families participating. If it had been rugby, everyone would have been there! Makes me feel like why should I differentiate for everyone else’s needs if no one is interested in supporting my interests?

How within-school communication could help teachers better respond to individual learners’ needs. Teachers also identified that more effective communication within the school community regarding teacher timetables, student class lists, timing and detail of school and department events and unit learning objectives would enable them to differentiate more effectively to meet individual students’ needs. Like whānau, Turin identified that communication needed to be differentiated to accommodate diverse teacher experience and need. Although an experienced teacher, as a new employee at the school, he felt that better communication could have enabled him to more efficiently establish relationships within the community and better differentiate for individual students’ needs,

> Things seem ‘assumed’ but I’m not sure if I’m the only one not knowing because I’m new or if we are all clueless. With ‘Meet the Teachers Night’ no [management or teachers] said where to go or what to do. It was like wine and cheese night instead of conferences but with crappy food” (individual interview).

Turin noted that the absence of meetings and inconsistent access to unit learning objectives within the science department made it difficult to plan for differentiation that equipped individual learners with the knowledge and skills necessary to achieve at the upper secondary science level (without repeating previous learning experiences).

> I think it would be good to talk together . . . I'm pretty much doing it on my own . . . If I wasn't experienced, I'd be in the crapper. Since I'm experienced enough, I've got my own stuff . . . When I came in last year I was hoping I could get learning outcomes so I could have my year plan done but [now] I'm hoping by the end of this term.

Alton and Sage agreed that the science teachers didn't collaborate "as much as we should" because "it's a time thing." Alton reflected that, "Communicating . . . hasn't happened" as much as he intended,

> Partly because I'll think of that lesson or that [differentiated] task specifically and improve it maybe the night before rather than have a chat [with colleagues well in advance], the kind of thing where it's reached the top of the must-do pile. Does that make sense? (teacher discussion).

In summary, despite teachers' decision to not target improved communication as a goal during the differentiated unit, the importance of effective, pro-active communication in establishing a differentiated classroom responsive and relevant to student and community need, remained evident.

Other emergent themes: Classroom management and teacher influence. In addition to the potential effective communication holds for increasing teachers' ability to differentiate science to meet student need, two other prominent themes emerged from the *Evaluating* data: (a) the importance of effective classroom behaviour management and (b) the influence individual teachers have in facilitating a responsive differentiated environment. Both are explained, with supporting interview excerpts, in the following sub-sections of this chapter.

Classroom behaviour management essential to differentiation that meets students' needs. As indicated by Figure 8.7, the theme of classroom behaviour management, or "discipline", was emphasised by students and their whānau as a critical component for fostering an effective differentiated teaching and learning that meets students' needs. As one father shared, most whānau felt there had "been improvement but there's still a long way to go" (father, two year 9 Māori females).

Both whānau and student focus group reflections tended to focus on what was ineffective rather than effective classroom management, citing

- level of noise – "sometimes they're bloody loud like today" (year 10 non-Māori male);
- type of language – "swearing" (year 9 non-Māori female) and
- off-task, distracting, or dangerous student behaviour – "fighting" (year 9 non-Māori female) and "throwing things and chasing around" (year 9 non-Māori male)

as key indicators that discipline was lacking and optimal differentiated learning was not happening.

> The trouble being that they don't have any discipline; they're not kept in line. And [my daughters] find that really difficult with the noise and the distraction in the class (father of two year 9 non-Māori females).

Student participants identified children of participating whānau as students that distracted the class, "they are like right behind us and they talk about the randomest stuff that has nothing to do with it. And they talk really, *really* loud!" (year 10 non-Māori female). However, no whānau identified their own children as the students likely to distract, "it's interesting because when I ask my girls about it they are the other way . . . they find it is the year 10 students who are mucking about" (father of two year 9 non-Māori females). "He's a capable child so able to articulate in class . . . although he sometimes gets the blame because he's arguing with others that disturb his lessons with talking" (mother, talented year 9 non-Māori female).

Student perspectives on the level of discipline improvement needed for optimal differentiated teaching and learning to take place varied greatly – both by teacher and within individual classrooms – as evidenced in the following focus group excerpts:

- "Well, it's [discipline] gotten a lot better to be honest" (Year 10 non-Māori female);
- "Discipline . . . was a bit better last year" (year 9 non-Māori male);
- "It's pretty loud, it's VERY loud!" (year 9 non-Māori male);
- "It's not really loud anymore" (year 9 non-Māori male);
- "Sometimes they'll muck about and he makes a joke or ignores it" (Year 9 non-Māori female) and
- "It's pretty good. Just every now and then it can get out of hand and that's just because Miss is just busy doing her own thing" (year 10 Māori female).

The diversity of student perspective demonstrated in these excerpts seems to indicate that teachers should consider differing student views and needs for the variety of noise level and type of behaviour permissible when establishing behaviour expectations within a differentiated science classroom environment.

Teachers agreed with students and whānau that classroom management was essential for an effective differentiated learning environment, sharing strategies they viewed as helpful. Sage talked about how planning and timing were essential tools she utilised to promote responsible, safe behaviour in effective, differentiated, hands-on science learning. "Yes, I just didn't want to give them the hearts too early [or] it ends up just chopping them up for nothing" (individual interview). Turin stated the importance of establishing an expectation for discipline early on in the school year, but doing it in a way that respected students' mana,

> I find with every class in the first week, I try and get them to toe the line. Consistency. And now as you can see, I've tightened up, I don't really want to play around. I do it quietly and make sure everyone knows I'm the boss . . ." (individual interview).

Whānau emphasised that effective classroom management and discipline needed to engage the scientifically talented as well as those who struggled or appeared uninterested in the subject to promote an effective differentiated learning environment for all,

> The classroom discipline the way [my daughters] described it is that [the teacher] is prepared to teach those that want to learn but not interested in teaching those that don't want to learn . . . The kids who supposedly don't want to learn that are mucking around probably don't realise that they actually do want to learn. . . . somehow there might be a switch that switches their attitude over (father of two year 9 non-Māori females).

Like Turin, whānau and students also valued "consistency" (mother, year 10 talented Māori male) of classroom management that upheld fairness and high expectations for all students, inclusive of gender, culture and ability.

> With the discipline side, there has got to be consistency . . . I think there's been improvement but there's still a long way to go . . . with every teacher you have the line in the sand for when good behaviour crosses to bad behaviour. And they're going to be at varying places but the closer they are the better is the best way I can put it.

As in the *Reconnaissance* phase, what really angered students was what they perceived to be biased treatment of teachers towards themselves or other classmates. "[Our teacher's] always with the one group of people" (year 10 Māori male). "Only helps people who need help and who are actually doing their work" (year 10 Māori female).

In summary, although classroom management was viewed by all participants as a crucial component of creating an effective differentiated science classroom that meets student needs, perceptions of the characteristics and attributes of a well-managed classroom varied both between and among teacher, student and whānau participants. Despite the difference in perspectives, some dominant themes emerged such as consistency of high academic and behavioural expectations with clear consequences for all students.

Teacher influence. Stakeholders stressed the vital role that individual teachers played in establishing or preventing an effective differentiated learning environment in "science specifically" (mother, talented year 10 Māori male) for students (see Figure 8.7). In addition to teachers' implementation of differentiation strategies, students and whānau frequently referred to having "a new teacher" (year 9 non-Māori male, open-ended survey response) or "better teacher I think" (mother, year 9 non-Māori male) as key contributing factors to improved learning. The mother of talented year 9 non-Māori male reflected of Turin, "sounds like a wonderful informative teacher – [his] humour makes the info stick and interesting lessons - keep him!" (whānau focus group). The mother of a year 10 male with learning difficulties voiced similar praise of Sage's efforts, "I said what's science like [this year]? And he said . . . he likes it because he has [Sage]. So, she's very relevant, very relaxed. She is just wonderful."

Students emphasised the importance of a positive teacher-student relationship for learning, "I think [learning] depends on what relationship you have with the teacher. It's harder to learn if you don't like the teacher. Or if you're not happy" (year 9 non-Māori female, focus group). The mother of a year 10 talented Māori male reflected that, "The personality of the teacher and even the style of the teaching can inspire passion." Table 8.2 shows the characteristics of a teacher who differentiated well and facilitated manaakitanga, as shared by participating teachers, students and/or whānau. Positive teacher attributes discussed ranged from competency in content knowledge and pedagogy to incorporation of humour in classroom teaching and learning.

Table 8.2: Participant-Identified Characteristics of a Teacher Who Differentiates Well and Facilitates Manaakitanga.

Teacher Characteristics	Participant Reflections
• Passionate about teaching	"Enthusiastic, yeah!" (year 9 non-Māori female, focus group). "It [learning science] should be exciting!" (Turin, individual interview).
• Competent in content knowledge and pedagogy	"You are still the major resource for the kids in that room in terms of learning" (Alton, teacher discussion).
• Knows students well and uses that knowledge to adjust teaching content, process and products appropriately	"She sort of knows people individually . . . knows what they're capable of and what they're not capable of . . . knows people's strengths . . . explaining in a way we can all understand" (talented year 10 Māori female, focus group).
• Cares about and enjoys helping students	"When we need help they help us" (year 10 non-Māori male with learning difficulties). "Giving like more students one-on-one [help]" (year 10 non-Māori female focus group).
• Uses humour to make learning fun and memorable	"Good at teaching ['cause] he makes classes funny and we can remember it good" (talented year 10 non-Māori male, focus group).
• Continually manages classroom behaviour fairly	"Consistent" (Turin, individual interview). "Doesn't kick you outside for nothing" (year 10 non-Māori male, focus group).
• Holds "high expectations" for all learners, including underachieving Māori	"Don't lower your expectations [of Māori kids]. Be fair but keep your expectations high" (Turin, individual interview).
• Fully present in the classroom, able to respond flexibly and appropriately to unexpected learner needs that might arise spontaneously	"With our module . . . I've used some of it, I've used most of it but I certainly haven't done it in that order and in the same way" (Alton, teacher discussion).

Teachers stressed the importance of teacher wellbeing in achieving a differentiated classroom. While discussing the merits of differentiated teaching and learning, Alton cautioned that differentiation is:

> one of those things that if we push too much we'll throw your work-life balance totally out of balance. So, I'm really reluctant for people to want to see [differentiation, particularly by task] as mandatory because you just end up . . . having everything completely out of balance (teacher discussion).

Even catching a simple cold can complicate classroom management,

> But then I got this big cold last week Friday and I've had it all week and it just makes things extra harder when you're extra tired . . . Can't you guys just read a book today? No that doesn't happen . . . Last weekend [my] kids and me stayed at home the whole weekend in hopes that the colds would magically disappear by Monday (Sage, individual interview).

Teachers reported setting work-life balance "boundaries" (Alton, teacher discussion) in the teaching profession as essential for helping experienced educators, "staying as a teacher and not quitting" (Sage, teacher discussion) and preventing burn-out. Turin described his policy of no school talk during his car-pool commute as a strategy for transitioning from work to home, "Last night Alton wanted to talk shop on the way home. Don't talk shop in my car!" Sage described the on-going conflict she felt between preparing for secondary science classes and looking after her own children, a similar age to the study's participants,

> In my heart, I think sometimes I'm very guilty of putting my kids after these kids. I'll go home and I just kind of ignore them, they'll go play basketball or watch TV so that I get [schoolwork] done. Whereas in the ideal world mummy would go and do stuff about it. Yeah, I feel bad about it . . . and then I feel guilty for my classes when they're not like as good as they could be.

Alton cautioned that the teaching profession, like many others, holds the potential for never-ending work. He warned that if "everything [is] completely out of balance, the quality of what you are or who you are as a person will suffer," negatively impacting students' learning. Both Turn and Alton observed that less time spent on planning often meant you were actually more open to diverging from your plan, resulting in better student-focused, responsive teaching in the classroom. As such, Turin and Alton preferred, "because I've been teaching for so long . . . [to] do one-word planning" (Turin, individual interview) over the traditional, lengthy lesson plans one might find in a preparatory teacher-training course. Alton declared that, ultimately, teachers needed to look after their own personal wellbeing not only for themselves but for "being the best you can be in the classroom" (teacher discussion) for their students.

Meta-Inferences

A review of my integrated quantitative and qualitative findings led to the development of 6 meta-inferences for the *Evaluating* phase. These meta-inferences, summarised in Table 8.3, influenced both teachers' monitoring efforts and the direction of my thesis discussion and conclusion chapters. The next section of this chapter explains each of these meta-inferences with supporting quantitative and qualitative evidence. I have also incorporated joint displays of excerpts from my integrated data findings to aid in thesis readability. Implications for differentiated teaching and learning, study limitations and potential for future studies are discussed in Chapter 9.

Table 8.3: *Evaluating* Meta-Inferences Derived from Integration of Qualitative and Quantitative Findings

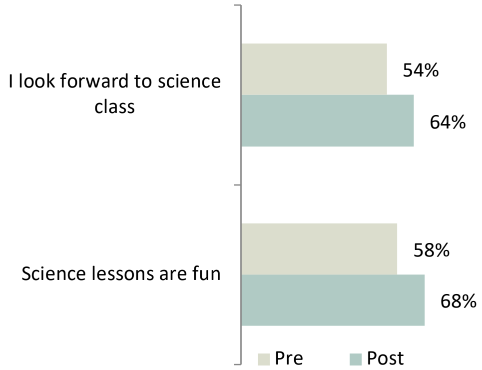
1. Differentiation of the science curriculum can improve student attitude towards learning science.
2. Differentiation of the science curriculum can increase student learning.
3. Teachers, students and whānau may hold differing perspectives of content relevance.
4. Teachers play a critical role in creating a responsive learning environment.
5. Teacher, student and whānau perceptions of the challenges to differentiation may vary.
6. Teachers are able to improve their ability to differentiate in the classroom.

Differentiation of the science curriculum can improve student attitude towards learning science. Figure 8.8 shows that teachers' efforts to differentiate the science curriculum for greater relevance, readiness and variety of process seemed to have a positive impact on student attitudes toward and enjoyment of learning science. More students reported looking forward to science class (pre-58%; post-68%) and viewed science lessons as fun (pre-54%; post-64%).

Meta-inference 1: Differentiation of the science curriculum can improve student attitude towards learning science.

Quantitative Evidence

Improvement in student attitude toward and enjoyment of science (*Evaluating* and *Reconnaissance* surveys, percentage of agreeing students):



Qualitative Evidence

Teachers

"It's [differentiation] been hard going. It's just been like full on. But I reckon the kids have been more keen or more interested" (Sage, individual interview).

Students

"Happy with how it [now] is." "My teacher is good. involves us has fun making learning fun" (year 10 Māori and non-Māori females, verbatim open-ended survey responses).

"I actually kind of enjoy what we've been doing to be honest – I just seem to be more excited to go to science" (year 10 non-Māori females, focus group).

"I'm not as naughty . . . because I know what we are meant to be doing now" (Year 10 non-Māori male, focus group).

Whānau

"He no longer moans about [science] class so all good" (mother, talented year 9 non-Māori male).

"That was certainly a good unit and they responded to it well" (father, two year 9 non-Māori females).

Figure 8.8: Mixed methods evidence supporting *Evaluating* meta-inference 1.

These improvements appeared to be true across the learning spectrum for Māori and non-Māori, male and female, scientifically talented and learning-disabled years 9 and 10 students. However, 1 Māori and 5 non-Māori individual year 9 students (21%) still reported either not looking forward to science (n = 3) or that science lessons weren't fun (n = 3) despite teachers' differentiation efforts (*Reconnaissance* and *Evaluating* surveys). Teachers, students and whānau described increased student engagement as evident in greater student interest in science, a reduction in "naughty" behaviour and the absence of "moans" about science class at home (see interview excerpts in Figure 8.8).

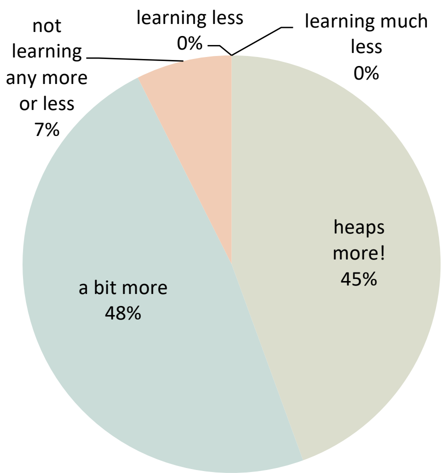
Differentiation of the science curriculum can increase student learning. As highlighted in Figure 8.9, most students (93%) and whānau reported teachers' differentiation efforts had increased student ability to learn science effectively. Similar to the perceived improvements in student attitude, students' perceived increase in learning was inclusive of Māori and non-Māori, male and female, scientifically talented and learning-disabled years 9 and 10 students. However, talented students and their whānau were still more likely than other participants to report an on-going need for more challenging content or faster pacing during focus group conversations:

- “We’re not getting on to the next thing . . . I’ve learned about the same thing 4 times!” (talented year 9 non-Māori male),
- “It’s more fun but it’s like a lot easier” (year 9 Māori female) and
- “Frustrated and bored” (mother, year 9 non-Māori male).

Meta-inference 2: Differentiation of the science curriculum can increase student learning.

Quantitative Evidence

Student self-assessment of learning changes post differentiated learning unit (survey):



Qualitative Evidence

Teachers

Differentiation is "pretty important ‘cause otherwise they think they can never achieve. I think they [students with learning difficulties] would always fail everything and put them off science probably" (Sage, teacher discussion).

Without differentiation, "they'll [talented students] just get bored and stagnate" (Alton, teacher discussion).

Students

"I'm actually learning this year!" "Yeah!" (year 10 Māori and non-Māori males, focus group)

"We [now] get to learn new stuff that we haven't done" (year 9 non-Māori male with learning difficulties, focus group).

"I understand some things more clearly now" (year 10 talented Māori female).

Whānau

"Just the fact that they have actually brought up the subject in discussion [at home] . . . I think they are learning more this year, my ones anyway" (father, year 8 non-Māori females).

"Yes. Yes. Yes!!! A better understanding of science as a whole that it impacts on every area of the natural world and the methods of cause and effect as well as the correct terms and names of materials” (mother, talented year 9 non-Māori male).

Figure 8.9: Mixed methods evidence supporting *Evaluating* meta-inference 2

Students with learning difficulties (particularly year 9 students in a class with year 10 students) were most likely to identify the content as too difficult or the pace as too quick, reflecting: “[our teacher] moves too fast” (year 9 non-Māori female, focus group) and “i [sic] really don’t like going to science because what we learn is hard and i’m [sic] shy to tell” (year 9 Māori female, open-ended survey response).

Teachers, students and whānau may hold differing perspectives of content relevance. Teachers' differentiation of the science curriculum for relevance was perceived positively among teachers, whānau and some students. Students reported an increase in connections of content to 'real life' (pre/post M = 2.33, 2.65) and products incorporating 'real science problems' (pre/post M = 2.28, 2.75); however, Figure 8.10 shows that quantitative data indicated very little change in students' views on the relevance of science to their lives (pre/post M = 1.38, 1.39) and culture (pre/post M = .93, 96). Furthermore, students' perceptions of the relevance of science to whānau actually dropped (pre/post M = .89, .75).

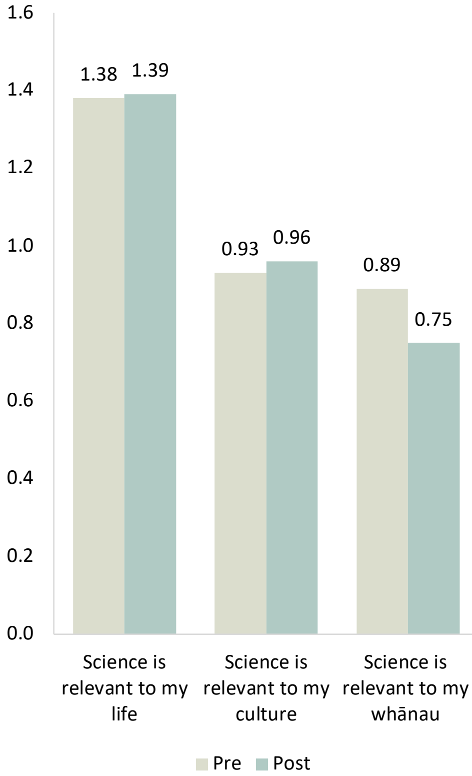
In reflecting on the reasons for the lack of change in students' perceptions of science relevance despite teachers' differentiated efforts, participants hypothesised that students' perceptions of reality might vary from teachers' reality – "what's real to them might not be what's real to us" (year 10 Māori female, focus group). Teachers and whānau debated both the definition of and role that relevance should have in 21st century teaching and learning, arguing that "the expectation of relevance maybe shouldn't always be there" (Alton, teacher discussion) as nearly anything could be argued to be relevant or irrelevant. The mother of a talented year 10 Māori male similarly questioned, "What's going to be relevant to what?" (Whānau shifted away from their *Reconnaissance* relevance emphasis on the importance of science instruction linking to students' interests, to a greater value and need for science content and skills that would prepare students for life as competent adults. With hesitance, whānau reported a need for trust in teachers' ability to select and teach content and methods relevant for students' current and future lives (both in and out of school), "I guess I have to say there is [trust needed] but my natural instinct is I don't trust teachers" (father, two year 9 non-Māori females). Whānau also reflected that more explicit articulation of connections between science content and methods and students' 'real lives' might help students see the applicability of what or how they are learning explaining,

> I think maybe you might be right for today's kids [explicit connections needed]. Back in my day . . . you learnt it because that was what was being taught. It wasn't until your senior years or you'd left school that you actually did learn that it was relevant. But perhaps today's kids are a bit different.

Meta-inference 3: Teachers, students and whānau may hold differing perspectives of content relevance.

Quantitative Evidence

Contrast in student perspectives of science relevance (*Evaluating* and *Reconnaissance* surveys, mean scale: 0 - Disagree, 1 - Not Sure, 2 - Agree):



Qualitative Evidence

Teachers

"That's interesting because I would have thought it would have been more relevant" (Sage, teacher discussion).

"But what we think of they might not think [as relevant] . . . The expectation of relevance maybe shouldn't always be there. It's been nagging in my head about whether or not we should…" [emphasise relevance so much] Alton, teacher discussion).

Students

"We are learning about more stuff that is relevant" (year 9 non-Māori female).

"If someone has an advantage to the topic like if they will get something in return. . . more likely they'll do it" (year 9 non-Māori female, focus group).

"[It's] not really [practical to life] but fascinating!" (year 9 non-Māori female).

"One thing that I don't like about science is the stuff that we're learning. . . it's alright but I sorta want to learn [agriculture science] because. . . I'm working for a bull breeder" (year 10 non-Māori male with learning difficulties).

"What's real to them might not be what's real to us" (year 10 Māori female).

Whānau

"In the sections. . . and the topics they've had so far. I think they are good relevant topics" (father if two year 9 non-Māori females).

"I don't think science has a lot of relevance when you're 12 or 13. . . I think ignore the children 'cause you don't know what you're going to do . . . I didn't particularly like physics, but I ended up doing so much physics that it wasn't funny. And I thought, 'Oh, I know this!' but I . . . couldn't have cared less when I was 15" (mother, year 10 non-Māori male with learning difficulties).

"I want it to be relevant whether [students] think it is relevant or not . . . Rather than how to know, teach [rangatahi] how to think. . . What is relevant in my mind is making them able to think, take in information, analyse it and come out with a problem or solution" (father, two year 9 non-Māori females).

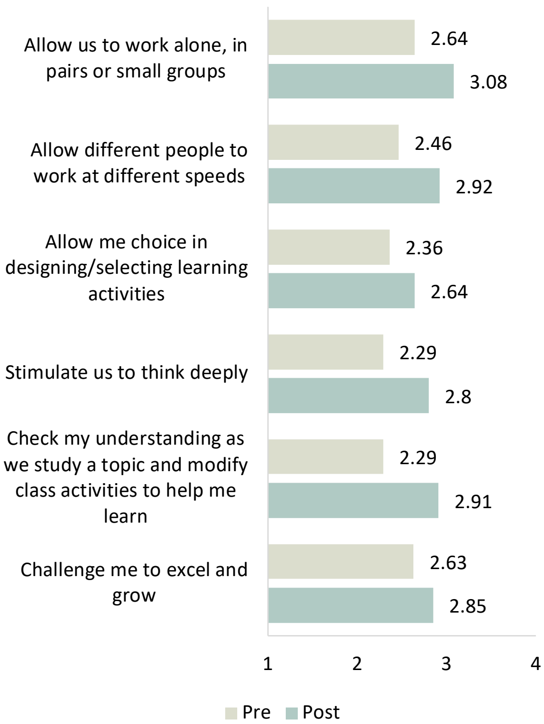
Figure 8.10: Mixed methods evidence supporting *Evaluating* meta-inference 3.

Teachers play a critical role in creating a responsive learning environment. Participating teachers, students and whānau repeatedly emphasised the important role an educator plays in establishing and maintaining a responsive learning environment that meets students' needs. The quantitative component of Figure 8.11 highlights students' belief that teachers' efforts to differentiate for relevance, readiness and variety did increase students' abilities to (a) collaborate with peers, (b) choose learning activities, (c) think deeply and (d) grow and excel. The qualitative component of Figure 8.11 provides insight into the attributes and skills of effective, responsive educators including: a willingness to help and interact with individual students, use of common vocabulary/language and an enjoyment of learning (fun). Māori and non-Māori teachers, students and whānau alike emphasised the concept of wairuatanga and the importance of an open, positive relationship between teachers and students, "It's harder to learn . . . if you're not happy" (year 9, non-Māori female).

Meta-inference 4: Teachers play a critical role in creating a responsive learning environment.

Quantitative Evidence

Contrast in pre/post student perspectives of learning environment (*Reconnaissance* and *Evaluating* surveys, mean scale with unsure excluded: 1 - Hardly Ever/Never 2- Sometimes, 3 - Frequently, 4 - Usually):



Qualitative Evidence

Teachers

"I've worked with some teachers who aren't very good teachers but they can do their jobs. And then you get these ones that are just amazing! They come in and they've got stuff going and they've got all these kids working. And I've thought, 'Wow, what's the difference? It's the whole wairuatanga thing'"(Turin, individual interview).

"Being the best you can be in the classroom [is vital], you are still the major resource for the kids in that room in terms of learning" (Alton, teacher discussion).

Students

"I think [learning] depends on what relationship you have with the teacher. It's harder to learn if you don't like the teacher. Or if you're not happy"
(year 9, non-Māori female, focus group).

"Like I can understand the teacher. And when we need help they help us" (year 10, non-Māori male with dysgraphia).

"She makes it fun (yeah) . . . like she's funny AS!!!"
(year 10 Māori male with learning dyslexia).

"She's actually giving like students more one-on-one [help] . . . She always comes over to me and explain things more . . . so that I fully understand" (year 10, talented Māori female, focus group).

Whānau

"Personality of the teacher and even the style of the teaching can inspire, passion too!"
(mother, year 10 talented Māori male).

"I said what's science like? . . . I know he likes it because he has [Sage] . . . very relevant, very relaxed. She is just wonderful (mother, year 10 Māori male with learning difficulties).

"Dynamics of the classroom this year, they're at least learning because . . . they want to learn in class" (father, two year 9 non-Māori females).

Figure 8.11: Mixed methods evidence supporting *Evaluating* meta-inference 4.

Teacher, student and whānau perceptions of the challenges to differentiation may vary. Although I had not intended to explore barriers to differentiated science teaching and had no quantitative questions exploring this topic, Table 8.4 shows that teacher, student and whānau participants identified challenges to effective differentiation during the *Evaluating* qualitative interviews and in open-ended survey responses. However, perspectives on the type and magnitude of the challenges as well as potential strategies to overcome them varied both between and among stakeholder groups. Table 8.4 shows teachers' responses tended to focus on the restriction of (a) time: "It's a time thing" (Alton, teacher discussion) and "I haven't had the chance to do as much as I'd like to" (Sage, individual interview) and (b) quality or quantity of resources such as size and structure of the classroom and access to laboratory materials/tools. Interestingly, many students and whānau, but no teachers, reported ineffective classroom management (most commonly referred to as "discipline") as the largest remaining obstacle to effective differentiation. Whānau reiterated their *Reconnaissance* perception of the importance of effective communication both within the school and between the school and community. Whānau reported that more pro-active communication would actually enable the community to help teachers reduce their differentiated workload and time pressures, particularly in the relevance area of linking science to the community. Teachers similarly identified a need for better communication and direction from school leadership to increase teachers' ability to identify and meet students' needs through differentiation.

Table 8.4: Mixed Methods Evidence Supporting *Evaluating* Meta-Inference 5

Meta-inference 5: Teacher, student and whānau perceptions of the challenges to differentiation may vary.					
Communication	"I think it would be good to talk together . . . I'm pretty much doing it on my own . . . If I wasn't experienced, I'd be in the crapper. Since I'm experienced enough, I've got my own stuff . . . When I came in last year I was hoping I could get learning outcomes so I could have my year plan done but [now] I'm hoping by the end of this term" (Turin, individual interview). "Communicating [within department] . . . That's the real issue to me. And partly because I'll think of that lesson or that task specifically and improve it maybe the night before . . . where it's reached the top of the must-do pile" (Alton, teacher discussion). "Senior management aren't really good with communicating either, there's nothing coming from them" (Turin, individual interview). "I reckon ask the students what they think" (year 10 Māori female). "I can understand his language!" (year 9 non-Māori female with dyslexia). "Have a family day, like see what we do in class!" (year 9, non-Māori female).	**Time**	"Very, very time poor. . . I haven't had the chance to do as much [differentiation] as I'd like to with like blood diseases and heart attacks. I kept going, looking at the list of topics and thinking I just need to get on to another topic now and then if I have time I'll come back" (Sage, individual interview). "I think things like differentiation by task with things that are written in five different levels for the same basic thing but to different degrees of difficulty [is not time efficient]. To be able to sit down and write that kind of stuff -- you'd be working 24-7!" (Alton, teacher discussion). Don't do as much [collaboration with the community] as we should. It's a time thing!" (Alton, teacher discussion). "Teacher[s] can't teach individually to 20 different children, [they've] got to do it for all . . . (Mother, talented year 10 Māori male).	**Classroom Management (Discipline)**	"Gotten a lot better to be honest (year 10 non-Māori female). "Just the slightest bit [need for increased discipline]. It's pretty good. Just every now and then it can get out of hand . . . because Miss is just busy doing her own thing" (talented year 10 Māori female). "Discipline. It was a bit better last year. . . It's pretty loud. It's VERY loud!" (year 9 non-Māori male). "[My son] finds . . . it takes a long time for the teacher to get them to be quiet so she can speak. So that's a lot of waste of . . . time . . . He gets frustrated with some of the behaviours" (mother, talented year 10 Māori male). "[My daughters] find [learning] really difficult with the noise and the distraction in the class" (father, two year 9 non-Māori females).
	"Our vagueness suggests that is has not been relayed very well. I'm not saying it hasn't been done" (father, two year 9 non-Māori females). "We're only getting what our children are telling us . . . We don't have any contact whatsoever with the actual teachers . . . Parents might be able to . . . assist with things . . . if there was communication with the home. Some of us that are farmers . . .can provide if we know we are having an animal home kill done . . . pigs, sheep, cows, whatever! If they want that kind of thing kept and frozen so that there is a supply" (mother, talented year 10 Māori male).	**Change**	"At any school you get change. Constant change at any school" (Turin, individual interview). "At term 2 i'm [sic] moving don't know were [sic]" (year 9, non-Māori, open-ended survey response). "We got a new teacher" (Year 10 non-Māori male).	**Resources**	"I've got 28, 29 [students] now. These [labs] are tiny. I understand why they would have built them tiny because they would have hopefully encouraged them to keep the class sizes small but it's not working like that" (Turin, individual interview). "Not a lot of textbooks which I've noticed 'cause I like doing some questions . . . The microscopes are horrible!" (Turin, individual interview). "It's weird having a big class . . . someone needs to go to the teacher's desk" (year 10 Māori female) "There wasn't enough [i-Pads] to go around . . . a bit annoying because I mean I can't really do . . . the research" (year 9 non-Māori male and talented Māori female).

Teachers are able to improve their ability to differentiate in the classroom. Figure 8.12 shows that participating teachers, students and whānau reported improvement in science teachers' abilities to meet diverse student needs. Evidence of growth from teachers' perspectives included shifts in confidence and competence (Figure 8.12) as well as teacher value in and use of differentiated strategies (Figure 8.4). Students reported improvements in assessment of and accommodation for student readiness – including learning difficulties, process variety, use of assessments that answered 'real science' problems, and more challenging "important" content. Whānau focus group participants similarly cited content, process and an openness to student questions as areas that had strengthened during the differentiated unit.

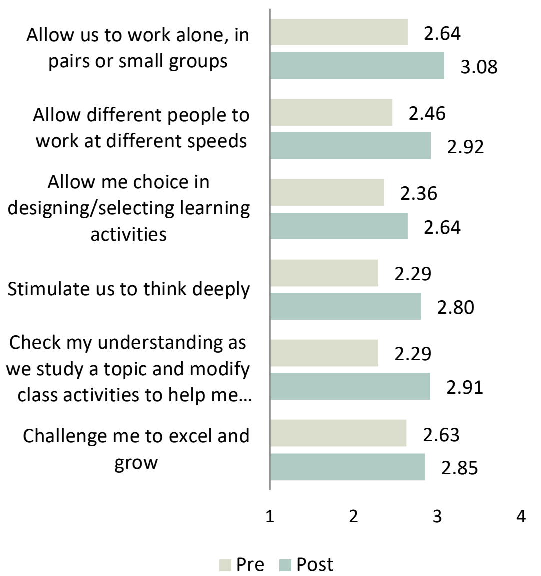
Meta-inference 6: Teachers are able to improve their ability to differentiate in the classroom.

Quantitative Evidence

Differentiated teaching confidence:
somewhat confident → confident
(Sage, *Reconnaissance* and *Evaluating* surveys).

Differentiation teaching competence:
advanced beginner → competent
(Sage, *Reconnaissance* and *Evaluating* surveys).

Contrast of pre/post student perspectives on teacher differentiation usage (*Reconnaissance* and *Evaluating* surveys, mean scale with unsure excluded: 1 – Hardly Ever/Never 2- Sometimes, 3 – Frequently, 4 - Usually):



Qualitative Evidence

Teachers

"Improving my planning to have activities which extend the more able while also giving time to improve engagement of the less able" (Alton, open-ended survey response).
More understanding of how students like/prefer to learn, if they are enjoying the learning they are more likely to understand and retain the information. Initiated more differentiated learning in the classroom (Sage, open-ended survey response).

Students

"Last year we were having mOre work and just sitting. Less practical – more writing on tests" (year 9 non-Māori male with learning difficulties, focus group).
"Now it's more like a whole variety of things . . . We try things out like we cut open a heart and lungs so far. And so, there's like more activities . . . I'm actually taking it in, that's what I mean" (year 10 non-Māori female, focus group).
"Science this year has been great so far! I'm able to express myself in class and feel comfortable in my work environment, I learn a variety of different things but they are all connected to something for example we are learning about the human body and will spend either a week or 2 talking about one specific part like the blodd,heart,lungs [sic] etc."
(year 10 talented Māori female, open-ended survey response).

Whānau

"Better subject matter . . . Better [processes]. Good information spoken and written for students . . . [teacher] give(s) info if question asked in class relevant to subject, even silly ones" (mother, year 9 talented non-Māori male).

Figure 8.12: Mixed methods evidence supporting *Evaluating* meta-inference 6.

Despite the positive growth in teachers' abilities to differentiate to meet diverse student needs, all stakeholder groups also identified areas that required further growth such as communication (see Table 8.4) and hands-on learning: "Deer's hearts . . . the only, as far as I'm aware, hands-on done all year. . . he says all they do is theory. Theory, theory, theory and it's boring!" (mother, talented year 10 Māori male).

Teachers were excited about the potential to differentiate for relevance in the upcoming physics unit on forces and motion,

> I still think of the relevance in 'able to put mathematical skills into understanding concepts in the world.' Like that fundamental physics stuff . . . has got more investigative space for us [than the human biology unit] . . .We can make our own rocket launchers . . . I'd like, I think we need to use more than one context. So, we don't just do cars or we don't just do crashes or we don't just do rockets. That way we're not sticking to the same thing.

Teachers indicated a desire and willingness to commit to on-going monitoring of teaching and learning responsive to school, classroom, teacher, student and whānau changing needs. As Turin reflected at the end of the unit, "I've got to . . . make sure they're learning!" (individual interview).

Summary and Monitoring

This chapter introduced the methods and findings of the *Evaluating* phase of my research. The selected methods and findings were chosen for their applicability in answering my fifth research question, "How does differentiation of the science curriculum impact student learning?" Analysis of the integrated quantitative and qualitative data collected from teachers, students and whānau indicated that teachers' implementation of a differentiated science curriculum for relevance, readiness and variety of process and product did increase their ability to meet many, but not all, students' learning needs. This chapter also presented 6 key differentiated meta-inferences that emerged from the *Evaluating* findings.

The findings and meta-inferences described in this chapter were shared with participating teachers at the end of the *Evaluating* phase (June, 2016). In response to the *Evaluating* feedback, teachers continued to modify their teaching to improve their ability to differentiate for relevance, readiness and variety. All three teachers committed to leading on-going *Monitoring* (phase 6) throughout the remainder of the 2016 school year (terms 2-4). As part of the *Monitoring* phase, I transitioned out of my active role as researcher and individual teachers took full control of differentiating in their classrooms. Participating students and whānau reported an increased use of hands-on, student-led exploratory investigations during the term 2 (June-July, 2016) physics rocketry unit; teachers reported stronger NCEA connections with a mock exam offered in term 4 (December, 2016). However, the discussion and conclusions introduced in the next chapter are drawn from the findings and meta-inferences of phases 1-5, *Reconnaissance* – *Evaluating*, as those were the MMAR phases in which I was most involved.

Chapter 9:
Discussion

Nāu te rourou, nāku te rourou, ka ora ai ngā tamariki.

With your basket (of knowledge) and my basket (of knowledge), the children will indeed prosper.

This research investigated existing years 9 and 10 science differentiated teaching and learning practices from the perspectives of Aotearoa New Zealand secondary science teachers, students and whānau. In so doing, it sought to counter the lack of evidence-based exemplars of effective, differentiated secondary science teaching and learning for all students, but particularly for students of non-dominant, Indigenous cultures in a mainstream classroom context. My study was innovative both in its (a) inclusion of and responsivity to teacher, student and whānau viewpoints, which although purported as important for developing responsive, inclusive teaching and learning, are rarely used to develop science curricula and (b) choice and incorporation of Ivankova's (2015) MMAR research methodology.

The preceding four chapters presented the methods used and findings arising from my application of Ivankova's MMAR framework to explore differentiated science teaching and learning within the rural, bicultural Aotearoa New Zealand community in which I teach. Chapters 5 and 6 explained the *Reconnaissance* exploration into existing differentiated science teaching practice from the perspectives of teachers, students and whānau. Chapter 7 described science teachers' efforts to collaboratively create (*Planning*) and implement (*Acting*) a differentiated science unit in response to community *Reconnaissance* input. Chapter 8 explored the *Evaluating* phase, as teachers, students and whānau shared their perspectives on the impact that teachers' differentiation for relevance, readiness and variety of process had on student learning.

In this chapter, I synthesise the research findings across the MMAR phases, situating them within the literature on inclusive education and differentiated instruction. My discussion is organised into three major sections:

- reflections on the research questions and findings,
- reflections on the research process and
- reflections on my learning as a researcher.

This study's unique contributions to research through (a) the creation of a framework for a community-based responsive approach to differentiation and (b) the application of Ivankova's MMAR framework in science education are discussed. Strengths and limitations of my study as a whole are also addressed. The chapter ends with implications for practice and research for differentiated science teaching and learning, and more widely, culturally responsive inclusive education that responds to diverse students' needs at the research site, within Aotearoa New Zealand and internationally.

Findings in Response to Research Questions

My colleagues and I were motivated to conduct this research by a desire to better meet the needs of years 9 and 10 science students in the rural Aotearoa New Zealand secondary school where we teach. I explored the applicability of differentiated science teaching and learning as a way of contributing to the evidence base of effective teaching and learning strategies for all science students – including Māori – within mainstream secondary science classrooms. To achieve this, my MMAR study was guided by five research questions. This section summarises my findings in response to my research questions; following that is a more critical review of the findings in relation to the literature.

The first question explored how differentiation was evidenced and understood by teachers, students and whānau. Participants' perspectives on the value in and teachers' use of differentiated science teaching and learning strategies revealed that participants perceived differentiation as a potentially effective classroom approach for meeting students' needs and all classroom teachers were currently incorporating some form of differentiation. These findings support the work of Maeng and Bell (2015), Tomlinson (2014), Kanevsky (2011, 2013) and Maker and Schiever (2005). My findings suggest that a responsive learning environment is critical to effective differentiation, as advocated by differentiation supporters including Maker and Schiever (2005) and Tomlinson and Imbeau (2010). However, my findings also indicate that teachers should engage and respond to community input when selecting which science differentiated teaching and learning strategies to incorporate in their classrooms. Participants reported that individual teachers differentiated variably and encountered many challenges when differentiating instruction.

The second question explored both how teachers worked together to plan a responsive differentiation unit and how they collaborated with me as a supporting researcher. Without colleague, student and whānau support for the differentiation investigation, none of this research would have happened. Although I initially designed my MMAR to explore differentiated teaching and learning as a practitioner-researcher, ethical concerns regarding power in the teacher/student relationship meant that I conducted no research on students in my own classes.

A year's study leave and enrolment in a PhD programme afforded me the privilege and time to access evidence-based research and tertiary researcher expertise previously inaccessible to me. It also enabled me to observe my colleagues' teaching strengths in action (we usually teach different classes simultaneously) and discuss science teaching and learning he kanohi kitea with teachers, students and whānau.

The majority of my support as researcher took the form of collecting and analysing community input to synthesise meta-inferences that guided teachers' responsive planning decisions and implementation actions. As researcher, I also supported educators through e-mail dialogue and digital platforms outside of school hours in response to teachers' needs. Teachers reported no other he kanohi kitea collective differentiated unit planning outside of the two MMAR scheduled *Planning* phase collaborative meetings. Participating teachers cited workload, competing school initiatives and a lack of scheduled department meeting time as barriers to he kanohi kitea differentiated collaboration. These findings align with challenges documented in the literature such as the need to "juggle busy schedules and workloads and manage conflicting priorities and commitments" (H. May & Keay, 2017, p. 87) for similar collaborative work in communities of practice (McDonald & Cox, 2017) and/or peer coaching (Hooker, 2013).

The next two questions explored how teachers adapted differentiation strategies designed for gifted students to understand, inform and implement science differentiation to meet the needs of all learners. My findings suggest that there is value in teachers using the differentiation materials designed for gifted learners (Kanevsky, 2011a, 2013; Maker & Schiever, 2010; Moje et al., 2004; Tomlinson, 2014) when the gifted differentiation principles and practices are adapted and implemented in response to community input. The concept of differentiating differentiation in response to teacher, student and whānau input, while novel, aligns with literature calling for more culturally responsive, funds-of knowledge orientated, community-driven teaching to close the prominent gap between high- and low-achieving students both in Aotearoa New Zealand and internationally (Berryman, 2017; Berryman & Eley, 2017; McKinley, 2005; McKinley & Gan, 2014; Moje et al., 2004; Moll et al., 1992; Tolbert, 2015). I have developed the concept of 3-D differentiation to represent differentiation responsive to community input, which is further elaborated later in this chapter.

Within my study, in response to community input on gifted differentiation strategies of high value and low usage, teachers chose to adapt the science curricula to differentiate for (a) content relevance, (b) student readiness and (c) variety and choice in product and process. Teachers differentiated for content relevance by increasing connections and applications to students' 'real lives' outside of school; this included a shift in focus in the year 9/10 human body biology unit from an emphasis on body systems to survival and first aid. Teacher assessment of student readiness was established through a variety of both (a) formal (planned) activities such as pre/mid/post unit surveys, quizzes, practicals and written tests and (b) informal (unplanned) actions such as questioning during teacher and student one-on-one and group interactions, conversations and discussions. My findings indicate that teachers accommodated learning readiness through (a) adjusting content skills and knowledge and (b) pacing (most often slowing down to accommodate low-ability learners). Teachers differentiated to include variety and choice in process and product through a variety of ways including increased hands-on learning (microscopes, heart-rate and exercise practical and heart and lung dissection), student-led inquiry (disease research projects), and virtual reality (human body system related activities such as conducting a C-section online).

My final question explored the impact that teachers' differentiation of the science curriculum had on student learning. Findings indicate that student engagement and learning in science improved in all areas in which teachers chose to differentiate, including: relevance of content, assessment and accommodation of student readiness and variety and choice in process and product. Although improvements were reported by most participating teachers, students and whānau, some individual participants, such as year 9 students with learning difficulties in the integrated year 9/10 class, and some scientifically talented students, reported unmet needs.

When investigating my specific research questions, I also discovered other findings that appeared relevant to creating a differentiated learning environment responsive to student needs. These included the (a) need for differentiation to be differentiated for teachers as well as learners, (b) paradox between planning and responsivity in differentiated teaching and learning, (c) ambiguity of relevance for teaching and learning, (d) potential that within school and home/school communication holds for enhancing or inhibiting differentiation and (e) advantages and challenges to using MMAR as a research framework. My research findings and their relation to existing science, differentiation and inclusive education literature are discussed next.

He Waka Eke Noa: Differentiation in 3-D.

The findings of this research indicate that differentiation has the potential to create a science teaching and learning environment that meets the needs of learners often excluded in Aotearoa New Zealand science education classrooms – students with exceptional talent, learning difficulties and of Māori or other non-dominant cultural backgrounds. These findings align with current literature advocating differentiated teaching and learning as an effective inclusion strategy in Aotearoa New Zealand and/or internationally (Kanevsky, 2011a, 2013; Riley, 2011; Tomlinson et al., 2003; Tomlinson & Imbeau, 2010).

However, my research findings also revealed that differences in perception created differing experiences of differentiation for teachers, students and whānau in both the

Reconnaissance and *Evaluating* phases. For example, while teachers and whānau reported that teachers had made great strides in increasing the relevance of science teaching and learning during the *Acting* phase, students perceived little change in the relevance of science to their lives, culture and whānau. The variety in participant perspectives on differentiated teaching and learning, both among and between teachers, students and whānau, aligns with Indigenous and non-Indigenous literature supporting the constructivist notion that different people experience reality differently (Crotty, 1998; Maxwell, 2012; G. Smith, Hoskins, & Jones, 2012). My findings suggest that in order for teachers to differentiate well to meet all students' needs, differentiation needs to be responsive – differentiating for teachers, students and whānau, as explained in the following subsections.

Differentiation needs to be differentiated for teachers. Although the importance of teachers as active contributors in their professional growth has been recognised in the recent Aotearoa New Zealand and global shift from top-down oriented initiatives toward teacher-led professional learning and development (Avalos, 2011; Bleicher, 2014; Osterman & Kottkamp, 2004), my research is the first to explore a teacher-initiated approach to expanding teachers' differentiation competency from within a bicultural Aotearoa New Zealand school setting.

A teacher-led approach to growing teachers' ability to differentiate curriculum aligns with Schon's (1983, 1991) model of reflective practice in which practitioners use their experience and expertise to improve professionally and better meet community needs. All participating teachers supported the science faculty's aim of increasing their capacity to differentiate to better meet learners' needs and worked collectively to achieve that goal. In doing so, teachers' differentiated professional learning linked, as Darling-Hammond (2009) suggested it should, with existing school initiatives and goals. Teacher collaboration throughout the differentiation planning and implementation process aligned with recommendations made by Maeng and Bell (2005) for future differentiated teaching and learning professional development research.

How individual teachers approached the department's differentiated targets, however, and the support each teacher sought to achieve these goals to overcome perceived barriers to differentiation such as time and limited resources (Table 6.3) varied greatly. Individual teacher's differentiated goals ranged from increasing capacity to challenge scientifically talented students to more consistent assessment of student readiness. Even teachers who described themselves as confident and competent identified specific areas of differentiation that they, as individuals, wanted to focus on, such as extending the curriculum to adequately challenge talented students or differentiating for process variety. How teachers implemented the collaboratively-designed differentiated curricula also varied from person to person, allowing teachers to make use of the diverse expertise that already existed within the school's science department as recommended by Ainscow et al. (2012) for effective educational change.

My research findings indicate that a teacher-led approach to developing and implementing a collaborative differentiated science curriculum in response to community input did indeed improve teachers' abilities to meet students' needs as perceived by teachers, students and whānau. Students reported improvements in teachers' assessment and accommodation of readiness through modifications to content, process and product. Process variety was identified by students as one of the biggest improvements during the *Acting* phase. Teachers and whānau described substantial improvements in content relevance. Many students, but not all, reported improvements in classroom manaakitanga, "Science this year has been great so far! I'm able to express myself and feel comfortable in my work environment, I learn a variety of different things but they are all connected" (talented year 10 Māori female).

Differentiation needs to be differentiated for students and whānau. My research findings suggest that in order for teachers to differentiate well to meet all students' needs, differentiation needs should not just be deferential (Kanevsky, 2011a) or defensible (Tomlinson, 2014) – adjusting curricula and learning environment based on student readiness, needs and learning profiles. Differentiation should also be responsive – incorporating and responding to community input of teachers, students and whānau. My research suggests that educators might better approach differentiation not as 2-dimensional (teacher and student dependant), as recommended by Hopgood and Ormsby (2011), but 3-dimensional, inclusive of the culturally responsive element of community input, which, for Indigenous students such as Māori, will need to be inclusive of whānau and iwi (Berryman & Eley, 2017).

My findings show that in seeking and responding to student and whānau input, science teachers were able to improve the effectiveness of their ability to meet students' needs. This appeared to be true even for differentiated strategies that teachers believed they had previously been incorporating well. For example, although teachers viewed variety of process as a differentiation strategy of high value (M = 4.33) and high usage (M = 3.67) (teacher surveys), *Reconnaissance* participating students and whānau reported an overemphasis on teacher-directed, content-knowledge transmission. This aligns with observations of Rawlins and Walkley (2016) that traditional teacher-orientated teaching practices remain the prevalent form of instruction in many Aotearoa New Zealand secondary school science classrooms. When participating teachers planned for and implemented greater variety of process during the differentiated unit, students and teachers reported notable improvements in the variety of how teachers taught, including the tools they used (Figure 8.12).

Participating teacher, student and whānau views supported the findings of Kanevsky (2011a) and M. Mills et al. (2014) that effective differentiation does not mean the use of individualised learning programmes for individual students every day. As Turin stated, “I don’t believe in full differentiation as defined by everyone doing their own thing” (teacher interview). Whānau participants of year 10 children on opposite ends of the learning spectrum likewise commented, “You can't meet the needs of 20 something people every period every subject” (mother of talented Māori male), “That's why you have to teach your children that sometimes you just have to get on” mother of non-Māori male with dysgraphia).

Teachers in this study, like M. Mills et al. (2014)’s participants, viewed workload as a key barrier in determining how and when to differentiate to meet student need, identifying differentiation is “one of those things that if we push too much will throw your work-life balance totally out of balance” (Alton, *Evaluating* teacher discussion). Participating teachers emphasised the importance of teacher wellbeing to enable teachers to be “the best you can be in the classroom . . . [as] the major resource for the kids in that room.” Teacher participants noted the importance of both planning for and responding to learners’ needs, as also observed in studies conducted by Maeng (2017) and Maeng and Bell (2015).

However, my research findings also indicate a phenomenon identified by Faber, Visscher, and Glas (2018) and Sawyer (2004) but rarely discussed in differentiated literature, that when the pendulum between differentiated planning and responding swings too far in either direction, it may decrease teachers’ abilities to meet learners’ needs. Participating teachers may be so well-planned that they may (a) struggle to deviate, “or change tact” (Turin, *Acting* interview) from their plan in response to spontaneous needs that become apparent in the classroom – “we will do an experiment and if we do something he will say it is wrong and he will just take over and like just do it himself” (year 9, Māori female, *Reconnaissance* focus group) or (b) find themselves needing to respond but with inappropriate materials or methods to do so, particularly for gifted students’ “extension work” (Casper, *Reconnaissance* interview). These findings align with Messiou and Ainscow’s (2015) view of the high level of unpredictability in the teaching field and the need for excellent teachers to respond flexibly. The findings also support Richards and Omdal’s (2007) observations that it is difficult for teachers to provide learning opportunities that appropriately challenge talented students and, thereby, prevent the ceiling effect from occurring in their classrooms.

Although teachers viewed their communication with the local community as sufficient, participating whānau identified areas that greater clarity of communication (i.e. advanced notice of science content, process and product) would enable whānau to help teachers better meet students' needs, particularly in the areas of relevance of science to 'real life' and the development of students' life skills such as organisation and time-management. My findings suggest that communication involving the community may be a way to overcoming some of the barriers to differentiation identified by de Jager's (2017) participating teachers such as limited time, workload, undisciplined learners and level of whānau support.

Differentiation needs to be culturally responsive. The findings of this research also suggest that differentiation, particularly differentiation developed in response to community input, has the potential to foster culturally responsive science teaching that meets the needs of students of non-dominant culture groups including marginalised Indigenous peoples such as Māori. Literature indicates that culturally responsive education may be critical to reversing the underrepresentation of non-dominant cultures in science education and bridging the existing science achievement gap among Aotearoa New Zealand secondary students (Bishop et al., 2003), of which Māori are currently disproportionately represented in the bottom end (Caygill et al., 2016).

The majority (93%) of participating Māori and non-Māori students reported learning more during teachers' implementation of the science curriculum, with 45% reporting they learnt heaps more. Many, but not all, Māori students reported better comprehension of content matter "I understand . . . more clearly now" (year 10 talented female) and greater enjoyment of science "it's more fun!" (year 9 female). Teacher and whānau perspectives also supported the idea that differentiation in response to community input resulted in improved student attitude towards learning science and increased student learning (Figures 8.8 & 8.9). This aligns with findings by Berryman and Eley (2017) that all learners, but particularly Māori, learn best under expert teachers willing to adapt their teaching in response to culturally relevant practices that are rooted in quality home, school and community relationships.

By engaging Māori teacher, student and whānau perspectives in the differentiation curricula development process, I recognise Māori tino rangatiratanga and Te Tiriti bicultural principles of partnership, participation and protection (Glynn, 2015; Ministry of Education, 2007). I respond to Ritchie (2016) and McKinley's (2005) call for those of the dominant cultural grouping to recognise and foster the transformative potential of the local Indigenous community. Turin's views, as an educator of Māori descent, align with findings of McKinley (2005; 2014) that Māori in the local community need to be involved in educational initiatives intended to raise Māori learner engagement and achievement, "As Māori we see this stuff and think, 'Okay, this Māori initiative is driven by a Pākehā. What Māori would want to do this? It was driven by a Pākehā in a university!'" (teacher interview). Engaging community input enabled participating teachers to reduce the plethora of differentiation choices, to, as recommended by Kanevsky (2011), prioritise and focus on a few feasible differentiated strategies viewed by the local community as holding the greatest potential for improving student learning. It also provided teachers with a way to foster what Webber's (2015) participating Māori secondary students identified as a critical component for academic success and strong Māori identity, "close, positive and supportive relationships . . . [between students,] whānau and teachers" (p. 145), helping to mitigate notions of whakamā amongst learners in the classroom.

Māori whānau offers to support teachers in overcoming differentiation barriers, such as time pressures and limited resources, support Rodriguez's (2015) assertion that creating more spaces for the underrepresented to be heard results in a greater diversity of solutions to the issues confronting local communities. Perhaps educators and education researchers should consider extending their student-centred 'funds-of-knowledge' (Moje et al., 2004; Moll et al., 1992; Tolbert, 2015) approach to teaching and learning to one that encourages active whānau participation, for participating whānau reported being extremely keen to connect their and other local expertise in farming and forestry with students' science learning to increase students' perceptions of the relevance of science to their lives outside of school. Students supported this concept, asking for more science learning that aligned with the local farming context, "I . . . want to learn [agriculture science] because I'm working for a bull breeder" (year 10 non-Māori male with learning difficulties).

My research makes strides toward aligning science teaching and research with Te Tiriti o Waitangi principles of partnership, participation and protection (Hayward, 2017), through engaging the Māori and non-Māori teachers, students and whānau whom teaching and learning initiatives are going to impact the most. My research responds to the calls of C. Rodriguez (2015) and Ritchie (2016) for science education academia to be more inclusive of culturally responsive local educators and researchers, to better understand the unique needs, perspectives and interests of their communities, particularly, bicultural Indigenous communities (McKinley, 2005; McKinley & Gan, 2014).

My findings suggest that science differentiation in response to community input may answer the call of Simpkins et al. (2009) for effective inclusive teaching strategies that are feasible for both new and experienced educators. Community-driven responsive differentiation might also help combat the state of mauri noho that many students of marginalised cultures have experienced in formalised education settings (Berryman, 2017; E. Durie, 2005), promoting mauri ora instead (Berryman, 2017; E. Durie, 2005).

Perhaps community-led responsive differentiated teaching and learning would enable teachers to better incorporate and respond to the vital but often "hidden voices" of students (Messiou & Ainscow, 2015) and whānau (Berryman, 2017) needed to truly uphold Tiriti o Waitangi principles of partnership, participation and protection (Ministry of Education, 2012a). In so doing, educators may begin to counter the on-going underrepresentation of non-dominant cultures internationally and in Aotearoa New Zealand in science education and science professions (C. Rodriguez, 2015).

3-D differentiation as a framework for inclusive teaching and learning can be visualised in a Māori waka hourua (double hulled sailing waka) as shown in Figure 9.1. The overall waka and the direction it moves represents each individual student's education journey. Because my research indicates differentiation in response to teacher, student and whānau input helps teachers better meet learners' needs, there are three sails. The rā matua (mainsail) represents the students supported by rā kei (mizzen) sails of teachers and whānau. All sails are upheld by pou manawa (masts) of communication – a key component of effective differentiation identified by participating Māori and non-Māori students and whānau that also aligns with the Tātaiako cultural competency of wānanga (Ministry of Education, 2012). Sense of belonging is represented by the taura pā (stays) to symbolise what participating teachers, students and whānau, as well as education literature (Berryman, 2017; Berryman et al., 2016; M. Durie, 2016; Poutama pounamu, 2017) identify as important – wellbeing and mutually beneficial relationships that nurture mauri ora and reduce whakamā for teachers, students and whānau, alike, during a learner's educational journey.

Because my research indicated that students' learning in and attitudes toward science improved when teachers modified curriculum in response to community input regarding differentiated strategies of high value but low usage, the papa noho (deck) represents differentiation strategies of content, product, process and affect identified by the community as having the most potential to meet individual student's needs. The deck is surrounded by a flexible kahokaho (railing) which characterises the value that study participants and literature (Tomlinson, 1999; Tomlinson & Imbeau, 2010) held for a responsive learning environment in which teacher/student/whānau interactions take place.

Participant emphasis on the importance of relevance is represented by the hiwi (hull), which supports the waka with evidenced-based curricula of teacher, student and whānau determined *relevant* knowledge, skills and understanding. At the stern, the hoe tere (steering paddle) represents the influence that local, regional, national and international community members such as iwi leadership, school leadership, education researchers and policy makers have in directing student learning as identified by participating teachers, students and whānau and research literature (Berryman, 2017; Bevan-Brown & Kenrick, 2013; Tomlinson & Allan, 2000). The paddle's design incorporates a triple pikorua (twist) symbolising multiple baskets of knowledge and the challenges and reconciliations of joining two or more cultures or people groups as illustrated in the complex bicultural history of Aotearoa New Zealand (Graham, 2002; Hayward, 2017; Lourie, 2016) and student and whānau focus group dialogue.

Figure 9.1: 3-D responsive differentiation visualised as a Māori waka hourua.

Given the bicultural context of my research setting in Aotearoa New Zealand, and my waka hourua visualisation of the key components of 3-D responsive differentiation, it seems fitting to give 3-D responsive differentiation a te reo Māori title, taken from the whakataukī (proverb), he waka eke noa, a vessel within which we are all in without exception. The relevance of this whakataukī and implications for research and practice are further explained at the end of this chapter. The next section of this chapter describes my findings in relation to using MMAR as an education research methodology.

Research Process.

The advantages and challenges encountered by researchers when conducting MMAR in educational or other social science research situation are not widely documented because MMAR is a novel and emerging research methodology (Ivankova, 2015, 2016). At the time that I conducted my research (2015-2016), I could find no MMAR-specific published research studies in the social sciences or elsewhere. The samples (Craig, 2011; Glasson et al., 2006; Kostos & Shin, 2010; Sampson, 2010) cited by Ivankova (2015) as MMAR exemplars, while using an approach similar to Ivankova's MMAR (2015), do not actually incorporate her framework. A further literature review at the time of writing this discussion (January, 2018) revealed that there have been three new articles published in the past year (2017) specifically referencing MMAR as a research methodology. In one, Ivankova (2017) describes how the work of Glasson et al. (2006) is an exemplar of the effectiveness of applied MMAR [despite the fact that Glasson's publication of her study (2006) well pre-dates Ivankova's (2015) creation of the MMAR framework]. The other two recently published studies use a MMAR approach to explore (a) the effects of fuel poverty on the lives of young people in Aotearoa New Zealand (K. C. O'Sullivan et al., 2017) and (b) research by Parker, Lieschke, and Giles (2017) on "normalising research in practice for nurses and midwives" (p. 1). Despite the differences in how Ivankova's MMAR framework was applied, all three studies indicate that MMAR holds potential for social science researchers wanting a framework from which to conduct meaningful research that impacts the lives of practitioners and the communities they serve such as nurses and mid-wives in New South Wales and youth researchers and teens in Aotearoa New Zealand.

This increase, albeit small, in MMAR-specific publications, seems to support Ivankova's (2015) assertion of a rise in popularity and use of MMAR in practitioner-led social science research. However, if MMAR as a research framework is to develop into a prominent, robust research methodology, it is important to consider both the advantages and disadvantages it holds for research. Because my study may be the first MMAR study to employ Ivankova's framework in an educational context within Aotearoa New Zealand and internationally, this section of the thesis shares my observations of the advantages and challenges of using MMAR to explore differentiated science teaching and learning.

Advantages to MMAR. I observed that the majority of benefits of using a MMAR approach to education research reflected the advantages one would find in conducting a well-designed practitioner-driven mixed methods education inquiry: allowing teachers to be active contributors to their professional growth to (a) address “real concerns” (Osterman & Kottkamp, 2004, p. 19) and (b) build on existing teacher expertise (Osterman & Kottkamp, 2004) over time in consideration of teacher workload as recommended by M. Mills et al. (2014).

However, one advantage unique to using the MMAR framework to guide my research design methodology was having a systematic approach which increased the rigour and credibility of my study, as advised by Edmonds and Kennedy (2013) and Ivankova (2015). I found using MMAR helped me to overcome the hurdle of developing a complex mixed methods study that incorporated diverse perspectives of teachers, students and whānau throughout the action research process. Ivankova’s (2015, 2017) MMAR framework enabled me to simply and accurately communicate my research design to participants, community members and other researchers as shown in Figure 5.1.

Challenges to MMAR. As with advantages to MMAR, many of the challenges I faced were similar to those practitioner-based researchers would experience when conducting any well-designed mixed methods study in a bicultural community including: potential conflict of interest, informed consent and respect for participant time and commitment, anonymity and confidentiality concerns and cultural considerations as a culturally-engaged researcher. Practitioner-led research over time in an authentic education setting inevitably encounters change, of which I experienced much. Unforeseeable changes in student enrolment, staffing, teacher timetables, class structure and school calendar required that I adjust when and how I embedded my mixed methods studies into the action research cycle.

I did encounter some challenges, however, that I believe are unique to using a MMAR approach and worth considering and addressing if MMAR is to become a more widely accepted research methodology, which I now explain:

- The lack of opportunity to simultaneously ‘Act’ and ‘Evaluate’. I found that participating teachers wanted to, and did, revise their planning through the *Acting* phase as they implemented the differentiated unit. Similarly, participating students were keen to provide, and teachers open to accepting and responding to, student feedback throughout the implementation phase. I found Ivankova’s (2015, 2017) current MMAR model, when adhered to as Ivankova (2015) conceptualised it, restricted practitioner responsivity and flexibility. If teachers can better meet student need by responding to student input before the end of the implementation phase, why restrict them from doing so?

- Uncertainty over the nature of and extent of the *Monitoring* phase. Responsive differentiated teaching and learning required teachers to continually monitor and adjust their teaching in response to community input. How does a practitioner-researcher know when (if ever?) to bring closure to the MMAR cycle?
- The challenge of developing and validating *Reconnaissance* and *Evaluating* meta-inferences (Venkatesh et al., 2016) and distinguishing them from the overall study meta-inferences. Current literature emphasises the challenge and importance of rigorous mixed methods analysis and integration to derive accurate meta-inferences (Ivankova, 2015; Onwuegbuzie & Johnson, 2006; Tashakkori & Teddlie, 2009; Venkatesh et al., 2016). With no literature exemplars of anyone doing this for MMAR, I found it extremely difficult to know how specific or generalisable each set of meta-inferences should be. My application of MMAR to an educational research setting leads me to suggest that MMAR practitioners consider adopting the terminology 'mega-inference' to distinguish between the overall study inferences and the *Reconnaissance* and *Evaluating* phase inferences.
- The challenge of how to best portray data gathered in a complex study incorporating multiple perspectives from a variety of participants over multiple phases. Although Guetterman, Fetters, and Creswell (2015) provide exemplars of joint displays of integrated mixed methods research, I could find none that were applicable to a MMAR study such as mine resulting in diverging, converging and fluid perspectives. Given that Rodriguez (2015) identifies a need for more spaces for heterogeneous voices of a non-dominant cultural background to be heard in order to promote diverse solutions to today's science education challenges, and Ivankova (2015) cites better comprehensive situation and problem analysis as a benefit of a well-integrated MMAR, exemplars of how to effectively present comprehensive situation analyses simply but accurately would be extremely helpful for future MMAR researchers.

MMAR, as any research approach, holds advantages and disadvantages that are both similar to and unique from other research methodologies. In describing the benefits and challenges I observed when utilising MMAR as a methodology for education research in differentiated science teaching and learning, I have opened the discussion on how practitioner-researchers might best use MMAR to foster meaningful change within their workplace responsive to their local communities.

My Learning as a Researcher

This section of the thesis reflects on my growth as a researcher. I begin by reiterating my motivation for conducting this study, as well as a brief description of prior research skills to provide context for my personal growth. I then describe key areas of my development as a researcher within the context of the Vitae Researcher Development Framework (RDF). RDF was first introduced in 2010 in the United Kingdom and enables early career researchers to assess personal knowledge, skills, behaviours and qualities against the "attributes and capacities of successful researchers" (Bray & Boon, 2011, p. 101). I have organised this section by three domains used by RDF to determine researcher capacity: (a) knowledge and intellectual abilities, (b) engagement, influence and impact and (c) research governance. Reflections related to RDF's fourth domain of researcher capacity, personal effectiveness, are integrated throughout (Bhakta & Ellen, 2016; Bray & Boon, 2011).

A return to research. When I began my PhD journey, I was not new to educational research, having previously completed a cross-age study (ages 5-18+) exploring students' ideas of water transport in plants for my science education master's thesis. However, in the years following the completion of my master's degree (2006-2015), I had conducted no formal research. I had chosen, instead, to focus on developing my classroom practice, particularly in the areas of awareness, understanding and competency in culturally relevant and responsive science teaching. My teaching journey led me to teach in a variety of international contexts including an affluent private school in Los Angeles, an Amerindian village accessible only by boat, a remote Micronesian island, and, eventually, rural Aotearoa New Zealand.

I was motivated to begin my PhD study when my school's science department discovered a lack of evidence-based Aotearoa New Zealand (and elsewhere) differentiated secondary science classroom materials. A need for differentiated science materials had arisen because management disestablished the years 7-9 GATE extension pull-out programme asking teachers to, instead, differentiate to meet gifted students' needs within mainstream subject classes. Achievement data and conversations with students and whānau indicated that teachers were not currently meeting learners' diverse needs, particularly for students at the ends of the learning spectrum, those with exceptional talent or learning difficulties, and Māori or other students of non-dominant cultural backgrounds.

As the school's only science teacher with a passion for research, I drafted a proposal for action research to explore and develop science differentiation materials. Much to my surprise it was accepted by not only the science faculty and school leadership, but also the Ministry of Education (TeachNZ Scholarship), Massey University (Vice Chancellor's Doctoral Scholarship) and

Japan's Society for Promotion of Science (fellowship to travel and participate in the 8th HOPE meeting with Nobel Laureates in Tsukuba, Japan). I found it exciting to carry out a study that was perceived to have value beyond the local community for whom I had designed it.

Knowledge and intellectual abilities and techniques to do research. I was both overwhelmed and excited by the changes to educational research that had occurred during my 9-year hiatus, most notably in the digital realm. Zoom, Endnote, Google audio documents, Express Scribe, NVivo, SPSS and Microsoft Word's review and track changes features were all new to me and required a steep learning curve. Thankfully, YouTube tutorials and Massey experts via Skype and Adobe Connect enabled me to work and overcome obstacles that arose. I found NVivo's digital coding to be much more efficient and effective than the photocopied thematic piles I had previously used.

One of the most substantial areas of growth in research technique during this study was my ability to collect and analyse mixed methods quantitative and qualitative data. Before conducting this research, I had only collected educational research data via photocopied paper surveys. My PhD research allowed me, for the first time, to facilitate and transcribe online surveys, individual and group interviews and classroom observations. As such, I definitely witnessed an evolution in my abilities to gather participant perspectives of science teaching and learning experiences throughout the phases of the MMAR study. Prior to the interviews I was confident that I would be able to utilise my classroom teaching skills to moderate interviews effectively, but during the transcription process found that I, rather than participants, had dominated much of the *Reconnaissance* discussion. I was disappointed in the brevity and vagueness of many participant responses, despite the open-ended structure of several questions. I, therefore, focused (successfully) on increasing in-depth participant responses in subsequent *Evaluating* interviews. As such, some themes are introduced in this thesis with limited supporting direct quotations in the *Reconnaissance* findings (I.e. teacher identified barriers to differentiation) but further delineated and supported by additional stakeholder evidence in later phases.

This research was my first opportunity to integrate qualitative data to extend and clarify my quantitative findings. I found this process quite challenging as it required me to analyse a plethora of quantitative data in a timely manner (before the school year ended) in order to probe emerging quantitative trends in the qualitative interviews. It would have been helpful to have had a larger time gap between quantitative surveys and qualitative interviews and classroom observations, however, aroha ki te tangata required that I worked within the teachers' requested schedule. Determining which qualitative themes to pursue in the *Planning* and *Acting* stages was also a challenge requiring insight and guidance from supervisors to overcome as I struggled to set aside many potentially interesting *Reconnaissance* findings and focus on a manageable few. As a person who tends to be a bit indecisive (not wanting to make a final decision due to potential of missing out on other opportunities), the research process has helped me improve my cognitive ability to competently assess options, make informed decisions and confidently move forward.

Research governance and organisation. RDF's governance domain addresses "knowledge of the standards, requirements and professionalism to do research" (Vitae, 2010) as cited by Bray and Boon, 2011, p. 101. Having previously conducted educational research in the United States of America, I was already familiar with research ethics and the ethics consent process. However, because this was my first venture into Aotearoa New Zealand research, this study helped me grow in my bicultural understanding of and integration of the Tiriti o Waitangi principles of partnership, participation and protection for teaching science and conducting educational research. Work by Aotearoa New Zealand researchers such as Berryman, Bishop, Cram, McKinley and Smith prompted me to continually evaluate the what, how and why of my research. These researchers also challenged me to question and probe my world view. I learned to incorporate current kaupapa Māori research teaching and learning practices so that I might, as a researcher and educator, better meet the needs of all students, including those of Māori and other non-dominant cultural backgrounds currently overrepresented at the bottom of the current secondary science achievement gap (Caygill et al., 2016). The continual, patient, encouraging mentoring of my Māori supervisor, Dr James Graham, contributed most to my growth in awareness, appreciation and consideration of biculturalism within Aotearoa New Zealand.

Engagement, influence and impact. The engagement domain of the RDF encompasses the knowledge and skills needed to work with others to encourage a wide research impact and includes the sub-domain of communication (Bray & Boon, 2011). This study, and the opportunities that have arisen from it, have definitely expanded my ability to engage and communicate with education practitioners and researchers in the development, implementation, analysis and sharing of my research design and findings. I applied for and received funding which enabled me to share and receive input on my work:

- within my local community where the research took place,
- nationally with (a) researchers at two Aotearoa New Zealand Association for Education Research (NZARE) Conferences and (b) educators at Aotearoa's New Zealand's first national primary science education conference
- internationally via the 8th HOPE meeting with Nobel Laureates and emerging science researchers in Japan.

Prior to conducting this research, I perceived myself to be an excellent communicator, having received praise/awards for my speaking, writing and teaching. What I quickly discovered in conducting, analysing and sharing my research, however, was a need to improve my ability to succinctly and clearly get my point across. Although I vastly improved in this area, my supervisors can attest that I still have a long way to go! I have also learned to be better at titiro, whakarongo . . . korero, listening and observing, before I speak. I have come to have a greater appreciation for the process of peer review and have learnt the importance of pausing and reflecting on (rather than immediately protesting or arguing) criticism of my work.

I learned to utilise Massey's online platforms such as EBSCOhost and STREAM to link with the Massey graduate research community without having to shift my young family from the rural community in which we live and work. I also learned to use social media, primarily in the form of Facebook and Skype, to connect with and develop a support network with other graduate students and emerging researchers beyond Massey in Aotearoa New Zealand and overseas. I plan to continue to nurture these relationships well beyond my thesis completion, as I have found forums such as the 'PhD and Early Career Researchers Parents' Facebook group especially helpful in maintaining a whānau/research balance and getting solutions to tricky challenges such as formatting hyperlinks correctly in Endnote reference lists.

Prior to this study, my sharing of Master's level research had been limited to a poster presentation at a science education research conference. NZARE's national conferences provided me with the opportunity to share my current work with education researchers beyond the sciences. I found it both exciting and intimidating to network and receive helpful input on individual and symposium full paper presentations from leading and emerging Aotearoa New Zealand researchers, many of whom I had been citing in my literature review but had not met before. Opportunities to give back and continue to network and learn with and alongside of Aotearoa New Zealand education researchers have arisen from these conferences as I am currently serving as the science education special interest group (SIG) coordinator and student caucus representative on the NZARE Council.

This PhD journey of MMAR design, implementation, analysis and sharing of findings has increased my understanding of educational research, my local community and myself. I have learnt to utilise new technology and tools to design, carry out, analyse and communicate culturally responsive mixed methods research relevant to the needs of my local community. I feel that my personal development has paralleled the cycling journey of my pre-school son (born at the start of this research) who is just about ready to shed his training wheels on his pedal bike. My next goal is to work towards publication of my responsive differentiation approach to inclusive education in both Aotearoa New Zealand and international education journals. Ultimately, I hope to find a job that enables me to both continue to teach early secondary students and contribute to excellent teacher, student and whānau-orientated, evidence-based educational research.

Conclusion: What I Have Found and Why It Matters

The remainder of this chapter explores my conclusions, describing what I have found and why it matters. The conclusion section is organised into three major categories: research contributions, research limitations and implications for practice and research. These are followed by final thoughts and a closing whakataukī that encapsulates the concept of 3-D differentiation and provides a pou (stake in the ground) to better meet all students' needs.

Research contributions. This research provides evidence that teachers' differentiation of the science curriculum, in response to community input, improved teachers' ability to equitably meet diverse student needs. Unlike previous studies, my research into differentiation engaged the community voice of teachers, students and whānau to develop a differentiated science unit responsive to learner needs. My 3-D, or he waka eke noa, framework for responsive differentiation challenges the dominant-culture orientated differentiated teaching and literature to reflect on how community involvement might impact teachers' ability to narrow the achievement gaps between students of dominant and non-dominant cultural backgrounds.

The variety of mixed methods tools modified and developed to gain a fuller understanding of community perspectives of science differentiation within an Aotearoa New Zealand bicultural context may provide a base for other educators of non-dominant cultures to conduct similar investigations into differentiation in the sciences or other teaching domains. My research, as Ainscow (2016) recommends, is vital for increasing international equity in education, contributing to "the development of new ways to reach out to all learners" [from] "different parts of the world" (p. 153).

My findings are the first to show evidence that differentiation in response to community input, or '3-D differentiation' may improve teachers' ability to meet students' needs, including learners often excluded in existing mainstream Aotearoa New Zealand and international science education such as students with learning difficulties, talented students and students of non-dominant cultural backgrounds. The overwhelming majority of participating years 9 and 10 Māori and non-Māori students reported improved learning when teachers implemented '3-D differentiation' and no students reported learning decreased learning. Māori and non-Māori teachers, students and whānau identified similar improvements in students' interest and attitude toward learning science.

My research is also unique in that it may be the first education study in Aotearoa New Zealand to utilise Ivankova's emerging MMAR (2015) approach to social science research. My research suggests that MMAR can provide an effective framework for community driven change, such as my work in differentiated science teaching and learning. However, my research also indicates that certain aspects of the current MMAR framework may need to be considered and addressed if MMAR is to move forward as a widely used, robust research methodology. My research identifies a need for:

- exemplars that employ MMAR from concept design to research completion [not just identified by Ivankova (2015) retrospectively as having characteristics that align to her proposed framework],
- greater flexibility and fluidity between the *Acting* and *Planning/Evaluating* phases,
- clarification of how and/or if *Monitoring* ends and closure (or on-going nature?) of the MMAR cycle and
- clarification of and exemplars for how to develop, validate, display and distinguish between meta-inferences of the *Reconnaissance* and *Evaluating* phases and whole study meta-inferences. I have proposed consideration of adopting the term *mega-inferences* as a way to refer to inferences derived from the overall MMAR cycle.

Research limitations. Limitations to instrument design and implementation for data collection and analysis specific to the individual phases of my MMAR study have been discussed by phases in the methods sections so that their implications could be considered in forming valid inferences. Such limitations included (a) bias in my research perspective, particularly as a non-Māori educator conducting practitioner-based research in the bicultural community where I teach and hold established power relationships with teaching colleagues, students and whānau, (b) acknowledgement that my on-going collegial relationship with study participants and the lack of anonymity in interview situations may have influenced how participants responded or kept some participants from disclosing information (Creswell, 2015a) and (c) the impact of decreased student enrolment on science staffing and class structure changes (merging of years 9 and 10 classes) and my ability to monitor collective change in teacher practice. In reflecting on my study as a whole, additional limitations also need to be considered to understand my conclusions such as data reduction and representative nature, as described in the following paragraphs.

Data reduction. While a strength of my 6-phase MMAR study was the incorporation, analysis and interpretation of multiple forms of qualitative data to better discern how differentiation of the science curriculum and learning environment was evidenced and understood by a diverse sample population of teachers, student and whānau, the plethora of qualitative information created a potential limitation in terms of potential data overload. Experts refer to the challenge of reducing the complexity and/or volume of mixed method data collected while “keeping enough complexity to make it both realistic and meaningful” (Olson & Jason, 2015, p. 394) as data reduction and consider it a critical component of mixed methods data analysis (Creswell & Plano Clark, 2011; Olson & Jason, 2015; Onwuegbuzie & Teddlie, 2003).

In identifying common themes and variances among teacher, student and whānau perspectives, I evidently made critical decisions regarding the selection of what to both include and exclude from the thesis findings reported in this chapter. I focused my findings on the differentiated strategies of highest value and lowest usage as perceived by stakeholder groups, and in so doing, may have excluded differentiated strategies that might have resulted in greater student learning and engagement.

Representative nature. Another limitation of my MMAR study is the impracticality of including every individual voice regarding the multiple components of science ‘student awareness’, ‘product’, ‘process, and ‘content’ differentiation (Ivankova, 2015). Therefore, even though the findings are taken from a diverse representative sample of the rural community, the patterns described do not necessarily represent the unique views that each teacher, student and whānau participant held regarding individual differentiated science and teaching strategies. Furthermore, I cannot assume that participant perspectives are representative of non-participant views, and the unique componentry of the rural school community within which I conducted my research restricts the generalisability of my study to other Aotearoa New Zealand or international science education contexts.

However, similarities in the challenges teachers face in providing an inclusive responsive classroom that equitably meets the increasingly diverse student needs in their classroom (Ainscow, 2016), both here in Aotearoa New Zealand and internationally, means that some of my findings may be relevant and applicable elsewhere. I provided detailed descriptions of my research design, instrument development and implementation and integrated mixed methods data collection to enable readers – both researchers and educators – to determine the applicability of my findings to their own unique situations.

Looking ahead – Implications for practice and research. Conclusions drawn from this MMAR study imply that differentiation of the secondary science curriculum has the potential to be an effective teaching and learning strategy for meeting diverse learners' needs, including students often excluded from science learning opportunities, such as those with exceptional scientific talent, learning difficulties or from non-dominant cultural backgrounds. However, the lack of differentiated training and evidence-based exemplars, combined with the plethora of purported differentiated teaching and learning strategies, can be overwhelming for teachers. He waka eke noa: differentiation in 3-D engages community input to help teachers prioritise differentiated teaching and learning strategies to differentiate responsively. My research indicates that 3-D differentiation may be a novel, culturally responsive, effective way to increase science engagement and learning for all students, including learners of non-dominant cultural backgrounds such as Māori, who are continually overrepresented at the bottom end of the on-going Aotearoa New Zealand science achievement gap. As such, my research provides educators with a new and potentially effective science teaching strategy for meeting diverse student needs.

An essential component of responsive differentiation is time for teachers to engage with the local community, particularly colleagues, students and whānau, he kanohi kitea. Study leave allowed me to assist teachers in the big-picture data collection, analysis and synthesis of meta-inferences. As such, policymakers may want to consider the importance of funding practitioner-led/research partnerships to promote sustainable community-based educational change. My findings also indicate the importance of excellent proactive communication both within school (leadership, teachers, students) and between home and school in overcoming barriers to differentiation such as teacher workload and limited resources.

As the first study to (a) explore the development of differentiated teaching and learning curricula in response to the perspectives of students, teachers and whānau, (b) investigate differentiated secondary science teaching and learning in a rural, bicultural Aotearoa New Zealand context and (c) utilise Ivankova's MMAR (2015) framework in research design and implementation, my research may provide evidence-based insight into direction for future education research including:

- the applicability and effectiveness of my framework for he waka eke noa: differentiation in 3-D to other school settings in Aotearoa New Zealand and elsewhere for meeting students' diverse needs (science, non-science, primary, secondary, tertiary, etc.);
- extending the measurement of 3-D differentiation on student learning beyond community perception to include quantifiable student achievement pre/post data;
- modification of research design and/or data collection instruments (language, structure,

content) to explore culturally relevant, inclusive, diverse 3-D differentiation elsewhere in Aotearoa New Zealand and internationally;

- further research into the elements of the 3-D model such as belonging and a collective sense of worth;
- exploration of the paradox between planning and responsivity in curriculum differentiation;
- examination of the impact of wellbeing on teachers' ability to create inclusive learning environments responsive to student need and
- use of MMAR framework in other community-based action research initiatives.

In summary, although this study was designed and implemented to investigate differentiated science teaching and learning within the school in which I teach, both the methodology and findings may have implications for researchers and educators beyond my local community, particularly in regards to meeting diverse needs of Māori students and other students of non-dominant cultures often excluded in current teaching practice.

Final thoughts. This research was driven by a desire to better meet the diverse needs of students in my secondary science classroom and expand the evidence base of effective inclusive teaching strategies. Like Vlaardingerbroek and Taylor (2016), I believed, and still do, that what matters most in education is how well students are learning and how teachers affect that learning. My study suggests that 3-D differentiation is a promising strategy for increasing the quality of culturally responsive science teaching and learning that meets the diverse needs of students from across the learning spectrum. In helping teachers determine which differentiated strategies are viewed by their local community as holding the most potential to increase student learning, he waka eke noa: 3-D differentiation may provide teachers, both new and experienced, with a feasible way to manage the plethora of differentiated strategies available to them and overcome some of the barriers to differentiation, including teacher workload. In so doing, I am contributing evidence-based research for inclusive teaching and learning strategies that encourage diversity, equity and fairness, and counter the on-going problem of inequity in education (Ainscow, 2016).

The closing whakataukī views the waka as a metaphor for each student's education journey, and serves as a pou in which 'we' – teachers, students, whānau and the wider community – together, promote a collective consciousness that affirms and asserts a sense of belonging and addresses diverse student needs through responsive 3-D differentiation.

He waka eke noa.

A vessel (within which) we are all in with no exception.

We are all in the waka together

The waka will not move in the right direction if we are not 'one'

All have a key role to play in the waka's journey

Partnership entails togetherness, cohesion and collectivity

Recognition and accommodation of diversity: difference, democracy, differentiation

To meet the unique learning needs of all students

Affirming and asserting learner belonging in the waka

And on any waters or shores that the waka may encounter in the future.

He waka eke noa.

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Appendix A.
Massey University Ethics Approval

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA

25 September 2015

Carrie Zwaag
[redacted]

Dear Carrie

Re: HEC: Southern B Application – 15/60
An investigation into differentiation in rural New Zealand secondary science

Thank you for your letter dated 25 September 2015.

On behalf of the Massey University Human Ethics Committee: Southern B I am pleased to advise you that the ethics of your application are now approved. Approval is for three years. If this project has not been completed within three years from the date of this letter, reapproval must be requested.

If the nature, content, location, procedures or personnel of your approved application change, please advise the Secretary of the Committee.

Yours sincerely

Dr Rochelle Stewart-Withers, Chair
Massey University Human Ethics Committee: Southern B

cc A/Prof Tracy Riley
Institute of Education
PN500

Prof John O'Neill, Director
Institute of Education
PN500

Mrs Roseanne MacGillivray
Institute of Education
PN500

Massey University Human Ethics Committee

Appendix B.
Staff Information Sheet

MASSEY UNIVERSITY
INSTITUTE OF EDUCATION
TE KURA O TE MĀTAURANGA

An Investigation into Differentiation in a Rural New Zealand Secondary Science Setting

INFORMATION SHEET

Researcher Introduction

My name is Carrie Vander Zwaag, although most of you already know me as Carrie and have worked with me as a Science teacher at the College for the past 6+years. I am currently a doctoral student at Massey University exploring ways to "differentiate" (meet the passions, interests, and needs of individual students) in junior science classrooms. I am supervised by Associate Professor Tracy Riley, a specialist in gifted and talented education, and Dr James Graham, who has an academic background in Māori education and is of Ngāti Kahungunu descent.

Project Description and Invitation

This project will explore both what is currently happening in Year 9 and 10 science classrooms and work with the students, whānau, and science teachers to explore how to collaborate together to extend the science department's ability to differentiate the science curriculum and learning environment to meet the individual needs and interests of our current students. An essential component of this is gaining the perspectives of all involved: students, whānau, and science teachers.

Teacher Participation Opportunities

You have been identified as a Year 9/10 science teacher at the college. I would like to invite you to consider participating in this study.

If you, as a teacher, choose to participate, you will have the opportunity to engage in a variety of differentiated activities including online surveys, focus groups, teacher observations, individual interviews and collaborative planning sessions over 2 years. A summary of the research: questions, phase, processes, and time commitment is provided on the table attached. Additional information about the research project as well as samples of the surveys used is available on my research webiste: sweetasscience.weebly.com.

Conflict of Interest

There is a potential conflict of interest given my position at the college. I am currently on Study-Leave from the college but have taught science classes at the college for the past 6 years. To manage this potential conflict of interest, I am not conducting research while working full-time as a science teacher at the college. This potential conflict of interest also serves to strengthen the legitimacy of the research as I have already established positive connections with staff, students, and whānau.

Data Management

The audio files from the recordings of the focus groups and collaborative planning sessions will be stored on a password protected computer that only I can access. No names will be included in the transcriptions and data will be reported anonymously. The questionaires and transcriptions will be stored separately from the consent. All data will be stored for five years and then destroyed. Paper data will be shredded and the audio files deleted. The audio-recording of the individual interviews will be transcribed by Massey transcribers who will sign a confidentiality agreement. Storage and destruction of all data and consent forms will be the responsibility of my supervisors in the Institute of Education at Massey University.

Page 1 of 3

**The school's name has been removed from the original documents to maintain confidentiality.*

Anonymity and Confidentiality
I will make every attempt to maintain the anonymity of the data by keeping everything reported in the surveys or discussed during the focus group discussions confidential. Pseudonyms (or 'pretend' names) will be used. The observational data will only be reported as mathematical totals and objective descriptions of the interactions. The college will be not be named. In any publications or presentations where findings may be presented, no identifying information will be included.

All participants will be provided access to a summary report of the results.

Participant's Rights

You are under no obligation to accept this invitation. Completion and return of the consent form indicate your willingness to participate. If you as a teacher decide to participate, you have the right to:

- decline to answer any particular question;
- withdraw from the study at any time;
- ask any questions about the study at any time during participation;
- provide information on the understanding that your name will not be used unless you give permission to the researcher;
- be given access to a summary of the project findings when it is concluded;
- ask for the recorder to be turned off at any time during a focus group discussion or collaborative planning session.

Project Contacts

If you have any queries or wish to know more please contact me:

Carrie Vander Zwaag
[redacted]

The contact details for the supervisors for my research are:

Tracy Riley	James Graham
T.L.Riley@massey.ac.nz	J.Graham@massey.ac.nz
(06) 350 5799 x84408	

Committee Approval Statement
This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern B, Application 15/60. If you have any concerns about the conduct of this research, please contact Dr Rochelle Stewart-Withers, Chair, Massey University Human Ethics Committee: Southern B, telephone 06 356 9099 x 83657, email humanethicsouthb@massey.ac.nz

Table of Opportunities for Teacher Participation in Research

Phase 1: Current Situation Analysis. ***Proposed Time Frame Terms 3 and 4, 2015 (September-December).***

Research Question(s) Addressed:
How is differentiation of the science curriculum (content, processes and products) and learning environment evidenced and understood by teachers, students, and whānau?

Proposed Action and Instrument Involved	*Mode*	*Time Commitment*
Introduction to project (Appendix C), Distribution and collection of consent forms (Appendices F & G)	Introduced during department meeting	15 minutes with kai
Science Teacher Differentiated Instruction Attitudes and Integration (Pre) Survey (Appendix R)	Online Survey during department meeting	20 minutes
Classroom Observations using Differentiated Learning Classroom Observation Template (Appendix 0)	Written Observations	1-3 class periods per teacher (1 hr each)

Phase 2: Collaborative Planning Phase. ***Proposed Time Frame Term 1, 2016 (February-April).***

Research Question(s) Addressed:
How can teachers, students and whānau work together collaboratively to plan for differentiation of the science curriculum (content, processes and products) and learning environment?

How can the principles and practices of differentiation for gifted and talented students be adopted to understand, inform and implement differentiation of the science curriculum (content, processes and products) and learning environment for all learners?

Proposed Action and Instrument Involved	*Mode*	*Time Commitment*
Focus Group: Work with Carrie to create professional development and Term 2 differentiated unit resources that address the needs and interests of teachers, students, and whānau (stemming from results of Phase 1 investigation into environment, content, process, product)	Focus Group discussions during department meetings, after or before school, during teachers' non-contact planning time (whatever works best for teachers involved)	5-10 hrs
Select group of scientifically talented students to be target group for student observations and monitoring of Phase 3 implementation	Select students based on student attitude survey, school's assessment data, and teacher recommendation	30 minutes

Phase 3: Implementation. ***Proposed Time Frame: Term 2 2016 (May-July).***

Research Question(s) Addressed:
How do teachers implement a collaboratively designed plan for differentiation of the science curriculum (content, processes and/or products) and learning environment?

Proposed Action and Instrument Involved	*Mode*	*Time Commitment*
Focus Group with Teachers to Discuss Implementation Challenges, Questions, Strategies, etc.	Audio Recording, Written Observations, Researcher Diary	1 to 3 meetings (45 minutes each)
Classroom Observations using Differentiated Learning Classroom Observation Template (Appendix O) or other tool created in Phase 2	Written Observations	1-3 Class Periods per teacher (1 hr each)

Phase 4: Evaluation ***Proposed Time Frame: Terms 3 and 4, 2016 (August-December)***

Research Questions Addressed:
How does differentiation of the science curriculum (content, processes and/or products) and learning environment impact learners' preferences, attitudes, performance and aspirations in sciences?

Proposed Action and Instrument Involved	*Mode*	*Time Commitment*
Science Teacher Differentiated Instruction Attitudes and Integration (Post) Survey (Appendix R)	Online Survey	20 minutes
Post-Implementation Focus Group with Teachers to Discuss Phase 3 and Overall Research Project based upon questions derived in Phase 3 and the original Science Teachers' Post Observation Interview Schedule (Appendix S)	Audio Recording, Written Observations, Researcher Diary	1 hr lunch with kai provided

Total Time Commitment: Up to 22 Hrs

Appendix C.
Staff Consent Form

MASSEY UNIVERSITY
INSTITUTE OF EDUCATION
TE KURA O TE MĀTAURANGA

An Investigation into Differentiation in a Rural New Zealand Secondary Science Setting

TEACHER CONSENT FORM - INDIVIDUAL

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

- I agree/do not agree to the focus groups and collaborative planning sessions being sound recorded.
- I wish/do not wish to have focus group and collaborative planning sessions recordings returned to me.

I do agree/do not agree to participate in this study under the conditions set out in the Information Sheet.

TEACHER'S FULL NAME: ____________________________________

TEACHER'S SIGNATURE ____________________________ DATE ____________________

PREFERRED MEANS OF CONTACT AND DETAILS:

Email/Phone/Address: ____

Format for Focus Group Consent Form (2015) Page 1 of 1

Appendix D.
Student/Whānau Information Sheet

MASSEY UNIVERSITY
INSTITUTE OF EDUCATION
TE KURA O TE MĀTAURANGA

An Investigation into Differentiation in a Rural New Zealand Secondary Science Setting

INFORMATION SHEET

Researcher Introduction

My name is Carrie Vander Zwaag, although most of you already know me as Ms. V. I have been a Science teacher at the College for 6+years, and am currently a doctoral student at Massey University exploring ways to "differentiate" (meet the passions, interests, and needs of individual students) in junior science classrooms. I am supervised by Associate Professor Tracy Riley, a specialist in gifted and talented education, and Dr James Graham, who has an academic background in Māori education and is of Ngāti Kahungunu descent.

Project Description and Invitation

This project will explore both what is currently happening in our school's Year 9 and 10 science classrooms and work with the staff to explore how to effectively differentiate the science curriculum and learning environment to meet the needs and interests of each individual student. An essential component of this is gaining the perspectives of all involved: students, whānau, and science teachers.

You have been identified as a Year 9 and 10 science student who will attend the college in 2016. We would like to invite you and your whānau to consider participating in this study.

Data will be collected in 4 phases from online surveys, focus groups, teacher observations, and collaborative planning sessions with staff. Additional information about the research project as well as samples of the surveys used are available on my research website: sweetasscience.weebly.com. A summary of the research process, timeline, and key questions is also provided in the table below.

Phase 1: Current Situation Analysis. ***Time Frame Terms 3 and 4, 2015 (September-December).***
Research Question(s) Addressed: *How is differentiation of the science curriculum (content, processes and products) and learning environment evidenced and understood by teachers, students, and whānau?*
Phase 2: Collaborative Planning Phase. ***Time Frame Term 1, 2016 (February-April).***
Research Question(s) Addressed: *How can teachers, students and whānau work together collaboratively to plan for differentiation of the science curriculum (content, processes and products) and learning environment?* *How can the principles and practices of differentiation for gifted and talented students be adopted to understand, inform and implement differentiation of the science curriculum (content, processes and products) and learning environment for all learners?*
Phase 3: Implementation. ***Time Frame: Term 2 2016 (May-July).***
Research Question(s) Addressed: *How do teachers implement a collaboratively designed plan for differentiation of the science curriculum (content, processes and/or products) and learning environment?*
Phase 4: Evaluation. ***Time Frame: Terms 3 and 4, 2016 (August-December)***
Research Questions Addressed: *How does differentiation of the science curriculum (content, processes and/or products) and learning environment impact learners' preferences, attitudes, performance and aspirations in sciences?*

Student Participation Opportunities

**The school's name has been removed from the original document to maintain confidentiality.*

If you, as a student, choose to participate, you will be engaged in a pre and post differentiated science learning online survey that will take approximately 30 minutes of science classtime to complete.

When?	What?	How Long?
Term 4, 2015	Student Online Survey	30 minutes of science classtime
Term 3, 2016	Student Online Survey	30 minutes of science classtime

All Year 9 and 10 students are also invited to take part in a focus group discussion at lunchtime to discuss in depth your perspectives of science at the college. Kai will be provided. Students will be informed of focus group dates and times through the school newsletter, the research website, and classroom science teachers. See the table below for a summary:

Other Opportunties:		
When?	What?	How Long?
Term 4, 2015	Student Focus Group (Interview and Discussion)	1 hr Lunch Period: 40 minute discussion followed by 20 minutes of kai
Term 3, 2016	Student Focus Group (Interview and Discussion)	1 hr Lunch Period: 40 minute discussion followed by 20 minutes of kai

Whānau Participation Opportunities

If you, as a caregiver, choose to participate, you will be engaged in a pre and post differentiated science learning focus group hui that will take approximately 1 hour and occur twice. The date, time and location of the hui will be determined based on whānau input. Kai will be provided.

Whānau Opportunties:		
When?	What?	How Long?
Term 4, 2015	Whānau Focus Group (Interview and Discussion)	Approximately 1 hr follwed by kai
Term 3, 2016	Whānau Focus Group (Interview and Discussion)	Approximately 1 hr follwed by kai

Compensation for Participants

All students who return consent forms by the indicated deadline (whether agreeing or disagreeing to participate) will receive lollies. Compensation for focus group huis for students and whānau will be in the form of kai as is fitting with the population and culture of the local community.

Conflict of Interest

There is a potential conflict of interest given my position at the college. I am currently on Study-Leave from the college but have taught science classes at the college for the past 6 years. To manage this potential conflict of interest, I am not conducting research while working full-time as a science teacher at the college. This potential conflict of interest also serves to strengthen the legitimacy of the research as I have already established positive connections with staff, students, and whānau.

Data Management

The audio files from the recordings of the focus groups will be stored on a password protected computer that only I can access. No names will be included in the transcriptions and data will be reported anonymously. The questionaires and transcriptions will be stored separately from the consent. All data will be stored for five years and then destroyed. Paper data will be shredded and the audio files deleted. The audio-recording of the focus groups will be transcribed by Massey transcribers who will sign a confidentiality agreement. Storage and destruction of all data and consent forms will be the responsibility of my supervisors in the Institute of Education at Massey University.

Anonymity and Confidentiality
I will make every attempt to maintain the anonymity of the data by keeping everything reported in the surveys or discussed during the focus group discussions confidential. Pseudonyms (or 'pretend' names) will be used. The observational data will only be reported as mathematical totals and objective descriptions of the interactions. The college will be not be named. No identifying information will be included in any publications or presentations where findings may be presented.

All participants will be provided access to a summary report of the results.

Participant's Rights

Students and whānau are under no obligation to accept this invitation. Completion and return of the consent form for you and your child will indicate your willingness to participate. If you and your child decide to participate, you have the right to:

- decline to answer any particular question;
- withdraw from the study at any time;
- ask any questions about the study at any time during participation;
- provide information on the understanding that your name will not be used unless you give permission to the researcher;
- be given access to a summary of the project findings when it is concluded;
- ask for the recorder to be turned off at any time during a focus group discussion.

Project Contacts

If you have any queries or wish to know more please contact me.

Carrie Vander Zwaag
[redacted]

The contact details for the supervisors for my research are:

Tracy Riley	James Graham
T.L.Riley@massey.ac.nz	J.Graham@massey.ac.nz
(06) 350 5799 x84408	

Committee Approval Statement
This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern B, Application 15/60. If you have any concerns about the conduct of this research, please contact Dr Rochelle Stewart-Withers, Chair, Massey University Human Ethics Committee: Southern B, telephone 06 356 9099 x 83657, email humanethicsouthb@massey.ac.nz

Appendix E.
Student/Whānau Consent Form

MASSEY UNIVERSITY
INSTITUTE OF EDUCATION
TE KURA O TE MĀTAURANGA

An Investigation into Differentiation in a Rural New Zealand Secondary Science Setting

STUDENT AND CAREGIVER CONSENT FORM – INDIVIDUAL

We have read the *Information Sheet* and have had the details of the study explained to us. Our questions have been answered to our satisfaction, and we understand that our participation is voluntary. We know we may ask further questions, opt not to answer questions, and/or withdraw from the study at any time.

STUDENT PARTICIPATION

STUDENT CONSENT

- I want to participate in the 2 online student surveys (during class) sharing my opinions of my college science experience **YES NO**
- I want to be a part of the student focus group discussion at lunch **YES NO**
  - If yes, what are your preferred day(s) of the week to have a focus group at lunch (kai provided)

    ____
- I **DO AGREE/DO NOT AGREE** to participate in this study under the conditions set out in the Information Sheet.

STUDENT'S FULL NAME: ____ **FORM CLASS** __________

STUDENT'S SIGNATURE: _________________________________ **DATE** ______________________

CAREGIVER CONSENT

- I **DO AGREE/DO NOT AGREE** for my child to participate in this study under the conditions set out in the Information Sheet.

  PARENT/GUARDIAN SIGNATURE: _______________________ **DATE:** ____________________

WHĀNAU FOCUS GROUP PARTICIPATION

I am interested in being involved in the whānau focus group. **YES NO**

- If yes, preferred day of week/time to have whānau hui (kai provided) ____________________
- Name(s) of people interested in partaking in whānau focus group ___________________________

PARENT/GUARDIAN SIGNATURE: _______________________ **DATE:** ____________________

PARENT/GUARDIAN NAME PRINTED: ____

PREFERRED MEANS OF CONTACT AND DETAILS: ____

Format for Focus Group Consent Form (2015) Page 1 of 1

**The school's name has been removed from the original document to maintain confidentiality.*

Appendix F.
Teacher Focus Group Consent and Confidentiality Agreement

MASSEY UNIVERSITY
INSTITUTE OF EDUCATION
TE KURA O TE MĀTAURANGA

An Investigation into Differentiation in a Rural New Zealand Secondary Science Setting

TEACHER FOCUS GROUP PARTICIPANT CONFIDENTIALITY & CONSENT FORM

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I agree not to disclose anything discussed in the Focus Group.

I agree to participate in this study under the conditions set out in the Information Sheet.

Signature: .... **Date:** ....

Full Name - printed ....

Appendix G.
Student/Whānau Focus Group Consent & Confidentiality Form

MASSEY UNIVERSITY
INSTITUTE OF EDUCATION
TE KURA O TE MĀTAURANGA

An Investigation into a Rural New Zealand Secondary Science Setting

STUDENT AND WHĀNAU FOCUS GROUP PARTICIPANT CONSENT FORM

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I agree not to disclose anything discussed in the Focus Group.

I agree to participate in this study under the conditions set out in the Information Sheet.

Signature: .... **Date:** ....

Full Name - printed ....

Format for Focus Group Consent Form (2015) Page 1 of 1

Appendix H.
Transcriber's Confidentiality Agreement

MASSEY UNIVERSITY
INSTITUTE OF EDUCATION
TE KURA O TE MĀTAURANGA

An Investigation into Differentiation in a Rural New Zealand Secondary Science Setting

TRANSCRIBER'S CONFIDENTIALITY AGREEMENT

I .... (Full Name - printed)

agree to transcribe the recordings provided to me.

I agree to keep confidential all the information provided to me.

I will not make any copies of the transcripts or keep any record of them, other than those required for the project.

Signature: .... **Date:** ....

Format for Confidentiality Agreement (2015) Page 2 of 2

Appendix I.
Teacher Differentiated Instruction Attitudes and Integration Survey

Part 1. Background Questions

Please answer these questions based on your current teaching practice in years 9 and/or 10 science.

1. How would you define *Differentiated Instruction*?

2. How would you rank your knowledge of differentiation techniques and strategies? Circle one.

None *Novice* *Advanced Beginner* *Competent* *Proficient* *Expert*

3. How confident are you facilitating differentiated learning in your classroom? Circle one.

Not at all Confident	*Somewhat Confident*	*Confident*	*Very Confident*	*Extremely Confident*

4. Do you differentiate for years 9 and/or 10 science students? Yes/No

If yes, please explain how you differentiate.

Part 2. Science Classroom Philosophy and Practice.

Please reflect upon and answer the following items. The letters in the left column indicate the level of importance to you, as a teacher, for each item. The numbers in the right column indicate level of use. All questions pertain to your work in years 9 and 10 science classrooms, only.

Left Column
A) Not important
B) Somewhat important
C) Neutral
D) Important
E) Essential

Right Column
1) Hardly ever/never
2) Sometimes/Have done a few times
3) Frequently do this
4) Do intentionally and often
5) Not sure

	Awareness of Student Differences	
A B C D E	I know individual student's interests	1 2 3 4 5
A B C D E	I relate my teaching and learning to individual student's interests	1 2 3 4 5
A B C D E	I know individual student's cultural backgrounds	1 2 3 4 5
A B C D E	I integrate cultural understanding into teaching and learning in a way that is inclusive, appropriate and relevant	1 2 3 4 5
A B C D E	I am aware of individual student's intellectual or specific learning disabilities (dyslexia, ADHD, dyspraxia, etc.)	1 2 3 4 5
A B C D E	My teaching addresses learning disabilities in a way that provides students with attainable challenge and growth	1 2 3 4 5
A B C D E	I know my individual student's life situations and how these instances may impact their learning	1 2 3 4 5
A B C D E	I consider individual student's life situations in my classroom teaching and learning	1 2 3 4 5
A B C D E	I am aware of my individual student's strengths and talents	1 2 3 4 5
A B C D E	I address individual student's strengths and talents in teaching and learning so as to extend and challenge them	1 2 3 4 5
A B C D E	I am aware of individual student's learning styles or preferences	1 2 3 4 5
A B C D E	I incorporate individual student's learning styles or preferences into teaching and learning	1 2 3 4 5

The **Content** I Teach is…		
A B C D E	Based on broad-based themes, issues and problems	1 2 3 4 5
A B C D E	In-depth and with breadth	1 2 3 4 5
A B C D E	Planned, comprehensive, related and mutually reinforcing	1 2 3 4 5
A B C D E	Grounded on clearly articulated objectives: students are cognizant of what they should know, understand and be able to do	1 2 3 4 5
A B C D E	Gender balanced and inclusive	1 2 3 4 5
A B C D E	Embedded with methods of inquiry: emulating the work of actual scientists	1 2 3 4 5
A B C D E	Engaged with science in real life contexts	1 2 3 4 5
A B C D E	Inclusive of variety, novelty, and diversity	1 2 3 4 5
A B C D E	Marked by opportunities for complex and sophisticated thinking	1 2 3 4 5
A B C D E	Inclusive of moral and/or ethical dimensions	1 2 3 4 5
A B C D E	Inclusive of Māori dimensions that directly relate to real life contexts for students and their whānau	1 2 3 4 5

Part 2. Science Classroom Philosophy and Practice (cont.)

Please reflect upon and answer the following items. The letters in the left column indicate the level of importance to you, as a teacher, for each item. The numbers in the right column indicate level of use. All questions pertain to your work in years 9 and 10 science classrooms, only.

Left Column
A) Not important
B) Somewhat important
C) Neutral
D) Important
E) Essential

Right Column
1) Hardly ever/never
2) Sometimes/Have done a few times
3) Frequently do this
4) Do intentionally and often
5) Not sure

	The **Processes** I Use…	
A B C D E	Pre-assess student readiness to adjust unit to meet individual needs	1 2 3 4 5
A B C D E	Assess throughout unit to gauge individual understanding and modify class activities based upon results	1 2 3 4 5
A B C D E	Incorporate a variety of instruction modes other than a textbook	1 2 3 4 5
A B C D E	Vary pace of instruction based on varying learner needs	1 2 3 4 5
A B C D E	Incorporate learners in designing/selecting learning activities	1 2 3 4 5
A B C D E	Provide a variety of support mechanisms (organizers, study guides, study buddies)	1 2 3 4 5
A B C D E	Adjust for diverse learner needs with scaffolding in learning activities	1 2 3 4 5
A B C D E	Adjust for diverse learner needs with tiering in learning activities	1 2 3 4 5
A B C D E	Adjust for diverse learner needs with compacting in learning activities	1 2 3 4 5
A B C D E	Adjust for diverse learner needs with student choice in learning activities	1 2 3 4 5
A B C D E	Provide tasks that require students to apply understanding	1 2 3 4 5
A B C D E	Provide tasks that require students to extend understanding	1 2 3 4 5
A B C D E	Assure all students must reach to challenge themselves to excel	1 2 3 4 5
A B C D E	Support a variety of activities including group and individual work	1 2 3 4 5
A B C D E	Group students for learning activities based on student readiness	1 2 3 4 5
A B C D E	Group students for learning activities based on individual student interests	1 2 3 4 5
A B C D E	Group students for learning activities based on learning preferences	1 2 3 4 5
A B C D E	Allow for group composition changes based on activity	1 2 3 4 5
A B C D E	Are open-ended, using discovery or problem-based learning strategies	1 2 3 4 5
A B C D E	Stimulate higher levels of thinking (analysis, synthesis, and evaluation)	1 2 3 4 5
A B C D E	Include a "service" or opportunity to share outcomes for the good of others like the community or whānau	1 2 3 4 5
A B C D E	Are "real" - mirroring the roles, skills and expertise of scientists	1 2 3 4 5
A B C D E	Are designed to develop skills in time management	1 2 3 4 5
A B C D E	Are designed to develop organisational skills	1 2 3 4 5
A B C D E	Promote planning skills and decision-making processes	1 2 3 4 5
A B C D E	Develop research strategies and skills	1 2 3 4 5
A B C D E	Utilise personal goal setting to direct and monitor growth	1 2 3 4 5
A B C D E	Are metacognitive - allowing students to reflect upon their own ways of thinking and learning	1 2 3 4 5
A B C D E	Require students to gather and interpret data representations	1 2 3 4 5
A B C D E	Encourage learners to use and critique evidence	1 2 3 4 5
A B C D E	Incorporate mentorship and/or involvement of professional scientists and content experts	1 2 3 4 5
A B C D E	Reflect Tātaiako cultural competencies (ako, manaakitanga, tangata whenuatanga, whanaungatanga, wānanga)	1 2 3 4 5

Part 2. Science Classroom Philosophy and Practice (cont.)

Please reflect upon and answer the following items. The letters in the left column indicate the level of importance to you, as a teacher, for each item. The numbers in the right column indicate level of use. All questions pertain to your work in years 9 and 10 science classrooms, only.

Left Column
A) Not important
B) Somewhat important
C) Neutral
D) Important
E) Essential

Right Column
1) Hardly ever/never
2) Sometimes/Have done a few times
3) Frequently do this
4) Do intentionally and often
5) Not sure

	The **Products** in My Classes…	
A B C D E	Have multiple modes of expression *(written, visual, oral, multimedia, etc.)*	1 2 3 4 5
A B C D E	Include a variety of formal and informal tasks	1 2 3 4 5
A B C D E	Incorporate student choice to work alone, in pairs or small groups	1 2 3 4 5
A B C D E	Incorporate student interest and choice	1 2 3 4 5
A B C D E	Are evaluated appropriately and with specific criteria including student self-evaluation	1 2 3 4 5
A B C D E	Include student self-evaluation	1 2 3 4 5
A B C D E	Are designed for an appropriate audience (not only the teacher)	1 2 3 4 5
A B C D E	Are the result of "real" problems, challenging existing ideas and creating new ones	1 2 3 4 5
A B C D E	Are developed using new and real scientific techniques, materials and ideas	1 2 3 4 5
A B C D E	Enable students, like scientists, to present ideas in a variety of ways, including models, graphs, charts, diagrams and written texts	1 2 3 4 5
A B C D E	Emulate real science: challenging students to connect new ideas to current and historical scientific knowledge	1 2 3 4 5
A B C D E	Emulate real science: challenging students to present their findings for peer review and/or debate	1 2 3 4 5
A B C D E	Are transformational of ideas, shifting students from the role of "consumers" to "producers" of knowledge	1 2 3 4 5

Part 3. Open Ended Responses & Acknowledgements

Please share any comments, suggestions, or clarifications regarding your answers on this survey.

Thank you for participating in this survey!

You may return to previous pages if you wish to modify your answers or, if finished, please click "done" below to submit your survey and exit.

Acknowledgements

This teacher differentiated instruction attitudes and integration survey was modified in content and context to fit a New Zealand rural secondary school classroom from*:*

Kiley, D. (2011). *Differentiated instruction in the secondary classroom: Analysis of the level of implementation and factors that influence practice.* (Doctorate of Education), Western Michigan University. Available from http://scholarworks.wmich.edu/dissertations/427/ (Paper 427).

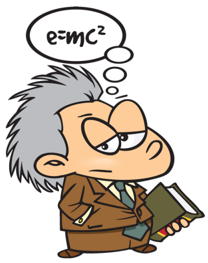
Whipple, K. A. (2012). *Differentiated instruction: A survey study of teacher understanding and implementation in a southeast Massachusetts school district.* (Doctoral dissertation.) Northeastern University, Boston. Available from ProQuest Dissertations and Theses database. (UMI No 3525802).

Other resources include:

Clipart Panda (2014). *50 images for science teacher clipart* [jpeg]. Retrieved from http://www.clipartpanda.com/categories/science-teacher-clipart

Ministry of Education (2007). *The New Zealand curriculum*. Wellington, NZ: Learning Media.

Riley, T. (2011). Qualitative differentiation for gifted and talented students. In R. Moltzen (Ed), *Gifted and talented New Zealand perspectives, 3rd Edition (pp. 276-303). Malaysia: Pearson.*



Appendix J.
Student Differentiated Instruction Attitudes and Integration Survey

Part 1. Science Related Attitudes Questions

Directions: Part 1 contains statements about practices that take place in science. There are no right or wrong answers. Your opinion is what is wanted. Think about how well each statement describes what science class is like for you at xxx College. For each statement select one of the following

Disagree - **if you disagree with the statement**
Not sure - **if you are not sure about the statement**
Agree - **if you agree with the statement**

Please give an answer for all statements. If any question is confusing, please feel free to ask Ms. V or your teacher for help/clarification. If you change your mind about an answer, you can go back and select a different answer instead.

1. I look forward to science lessons.	Disagree	Not Sure	Agree
2. Science lessons are fun.	Disagree	Not Sure	Agree
3. I enjoy the activities we do in science.	Disagree	Not Sure	Agree
4. Science is one of the most interesting school subjects.	Disagree	Not Sure	Agree
5. I want to find out more about the world in which we live.	Disagree	Not Sure	Agree
6. Finding out about new things is important.	Disagree	Not Sure	Agree
7. I enjoy science lessons at this college.	Disagree	Not Sure	Agree
8. I like talking to my friends about what we do in science.	Disagree	Not Sure	Agree
9. We should have more periods of science each week.	Disagree	Not Sure	Agree
10. I feel satisfied after a science lesson.	Disagree	Not Sure	Agree
11. Science is relevant to my life.	Disagree	Not Sure	Agree
12. Science is relevant to my culture.	Disagree	Not Sure	Agree
13. Science is relevant to my whānau.	Disagree	Not Sure	Agree

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Student Survey Acknowledgements

This survey was modified in content and context to fit an Aotearoa New Zealand rural secondary school classroom from:

Helding, K., & Fraser, B. (2006). Modified attitude scale. Retrieved from: http://www.chemeng.ntua.gr/courses/ped2/files/WIHIC.pdf

Whipple, K. A. (2012). Differentiated instruction: A survey study of teacher understanding and implementation in a southeast Massachusetts school district. (Doctoral dissertation.) Northeastern University, Boston. Available from ProQuest Dissertations and Theses Database. (UMI No 3525802).

Other resources include:

Clipart Panda (2014). *50 images for science teacher clipart* [jpeg]. Retrieved from http://www.clipartpanda.com/categories/science-teacher-clipart

Ministry of Education (2007). *The New Zealand curriculum*. Wellington, NZ: Learning Media.

Riley, T. (2011). Qualitative differentiation for gifted and talented students. In R. Moltzen (Ed), *Gifted and talented New Zealand perspectives, 3rd Edition (pp. 276-303). Malaysia: Pearson.*

Part 2. Choosing the Importance of and Frequency of Science Learning Activities

Directions: Below is a list of practices and activities that many science classrooms around the world use. Please reflect upon your own experience in science and answer the following items. The letters in the left column indicate the level of importance they have for you, as a student. The numbers in the right column indicate how often you think this happens in science classes at xxx College.

Left Column
A) Not important
B) Somewhat important
C) Neutral
D) Important
E) Essential

Right Column
1) Hardly ever/never
2) Sometimes/Have done a few times
3) Frequently do this
4) Do intentionally and often
5) Not sure

There are no right or wrong answers. If any questions are confusing, please feel free to ask Ms. V or your teacher for help/clarification. *Please attempt to answer every question.*

Science Teachers' Awareness of Student Differences		
A B C D E	My science teachers know what I am interested in	1 2 3 4 5
A B C D E	My science teachers relate my interests to our classwork	1 2 3 4 5
A B C D E	My science teachers know what I already know about the topic we are studying	1 2 3 4 5
A B C D E	In science class I learn new things (not just relearn what I already know)	1 2 3 4 5
A B C D E	My science teachers know my cultural background	1 2 3 4 5
A B C D E	My science teachers link my cultural background into our classwork	1 2 3 4 5
A B C D E	My science teachers know the areas of my learning difficulties	1 2 3 4 5
A B C D E	My science teachers address my learning disabilities in a way that supports me to grow/improve	1 2 3 4 5
A B C D E	My science teachers know about my life outside of school	1 2 3 4 5
A B C D E	My science teachers consider my life outside of school (commitments, whānau, etc.) in our classroom teaching and learning	1 2 3 4 5
A B C D E	My science teachers are aware of my individual strengths and talents	1 2 3 4 5
A B C D E	My science teachers challenge me to grow and excel	1 2 3 4 5
A B C D E	My science teachers know my learning styles or preferences	1 2 3 4 5
A B C D E	My science teachers incorporate my learning styles or preferences into our teaching and learning	1 2 3 4 5

The Topics We Learn in Science		
A B C D E	Have big themes that deal with important issues and problems	1 2 3 4 5
A B C D E	Have a lot of variety but also allow us to study them in-depth	1 2 3 4 5
A B C D E	Seem well-planned	1 2 3 4 5
A B C D E	Have clear objectives: we are aware of what we need to know, understand and be able to do	1 2 3 4 5
A B C D E	Encourage both genders (male and female) to succeed	1 2 3 4 5
A B C D E	Encourage us to think and question like actual scientists	1 2 3 4 5
A B C D E	Link to science in everyday life	1 2 3 4 5
A B C D E	Provide opportunities for complex and sophisticated thinking	1 2 3 4 5
A B C D E	Include moral and ethical issues and ideas	1 2 3 4 5
A B C D E	Are inclusive of Māori Tātaiako *(Kotahitanga – unity, Wānanga – sharing of knowledge between students and teachers, etc.)*	1 2 3 4 5

Left Column
A) Not important
B) Somewhat important
C) Neutral
D) Important
E) Essential

Right Column
1) Hardly ever/never
2) Sometimes/Have done a few times
3) Frequently do this
4) Do intentionally and often
5) Not sure

The Processes We Use in Science		
A B C D E	Include testing my knowledge to determine what I already know before we begin a new topic	1 2 3 4 5
A B C D E	Involve checking my understanding as we study a topic and modifying class activities to help me learn what still confuses me	1 2 3 4 5
A B C D E	Use many different ways to learn (not just reading from a book)	1 2 3 4 5
A B C D E	Allow different people to work at different speeds	1 2 3 4 5
A B C D E	Allow me to have choice in designing/selecting learning activities	1 2 3 4 5
A B C D E	Use a variety of tools to support my learning (study guides, lab templates, partners)	1 2 3 4 5
A B C D E	Provide tasks that require me to apply and extend understanding	1 2 3 4 5
A B C D E	Help me challenge myself	1 2 3 4 5
A B C D E	Support a variety of activities including group and individual work	1 2 3 4 5
A B C D E	Allow us to be in different groups based on our interests and learning needs	1 2 3 4 5
A B C D E	Allow us to work in different groups depending on the activity	1 2 3 4 5
A B C D E	Challenge us to discover and problem-solve	1 2 3 4 5
A B C D E	Stimulate us to think deeply (critically)	1 2 3 4 5
A B C D E	Include a "service" component where we can share our information for the good of whānau and the community	1 2 3 4 5
A B C D E	Are "real" science - mirroring the roles, skills and expertise of scientists	1 2 3 4 5
A B C D E	Help me improve my time-management abilities	1 2 3 4 5
A B C D E	Help me with my organisational skills	1 2 3 4 5
A B C D E	Help me improve my planning and decision-making skills	1 2 3 4 5
A B C D E	Help me grow in my ability to set, meet, and reflect on personal goals	1 2 3 4 5
A B C D E	Help me to improve my research skills	1 2 3 4 5
A B C D E	Help me to reflect upon my own ways of thinking and learning	1 2 3 4 5
A B C D E	Require me to gather and interpret data representations	1 2 3 4 5
A B C D E	Encourage me to use and critique evidence	1 2 3 4 5
A B C D E	Involve professional scientists and content experts	1 2 3 4 5

Left Column
A) Not important
B) Somewhat important
C) Neutral (don't care)
D) Important
E) Essential

Right Column
1) Never/Hardly ever
2) Sometimes
3) Frequently
4) Usually
5) Not sure

	The Products We Make in Science	
A B C D E	Use a variety of options (tests, labs, projects, reports, etc.)	1 2 3 4 5
A B C D E	Include both formal (end of topic) and informal (day to day) tasks	1 2 3 4 5
A B C D E	Allow us to work alone, in pairs or small groups	1 2 3 4 5
A B C D E	Allow me to choose how I show what I have learned based on my interests	1 2 3 4 5
A B C D E	Have a marking schedule with clear expectations that is easy to follow and understand	1 2 3 4 5
A B C D E	Are evaluated by both the teacher and myself	1 2 3 4 5
A B C D E	Include more audiences than just the teacher and classmates	1 2 3 4 5
A B C D E	Answer "real" science problems	1 2 3 4 5
A B C D E	Challenge existing ideas	1 2 3 4 5
A B C D E	Allow us to not just memorise but also create new knowledge	1 2 3 4 5
A B C D E	Use new and real scientific techniques, materials and ideas	1 2 3 4 5
A B C D E	Use real science, challenging us to connect our ideas to current and historical scientific knowledge	1 2 3 4 5
A B C D E	Encourage us to present ideas in a variety of ways, including models, graphs, charts, diagrams and written texts	1 2 3 4 5

Part 3. Open-Ended Responses

Please share any comments, suggestions or clarifications regarding science class and your ability to learn and challenge yourself that you think might be helpful for the Differentiation Project. Please reflect on your entire science experience at xxx College (not just this year).

If you want to change any previous answers click on the PREV button below and modify your answers.

When you are satisfied with your answers and your survey is complete, please click on the <u>DONE</u> button below to finish and exit.

Thank you for your help!

Appendix K.
Modifications Made to Teacher and Student Surveys for the *Evaluating* Phase

Additional Questions Added to Teacher Survey

How has being involved in this research influenced what/how you teach in the classroom?

Additional Questions Added to Student Survey

1. Please take the time to provide any comments, suggestions, or clarifications regarding science in 2016 and your ability to learn and challenge yourself that you think might be helpful for the Differentiation Research Project.

2. List any specific feedback for your science teachers as they work to develop differentiated units of learning for terms 2-4 that are both interesting and challenging. ***Your comments will remain confidential, so feel free to share about both the good and bad!***

3. What is your 2016 science learning experience like when compared to previous years?

- ○ I am learning heaps more!
- ○ I think I am learning a bit more this year.
- ○ I don't think I am learning any more or less than before.
- ○ I think I am learning less this year.
- ○ I am learning much less than in previous years.

4. Over the summer, the science teachers reviewed summaries of your responses to the previous online survey. Do you feel your responses have been used by teachers to improve what and how you learn in your science classes in 2016?

- ○ Definitely!
- ○ Yes! I think some of my responses have been used by teachers to improve how we learn in science.
- ○ Maybe? Not sure.
- ○ Not really.
- ○ Definitely not! I feel like my responses have been ignored and we have the same issues as last year!

Please explain (optional).

5. Are you interested in participating in the final lunch-time focus groups in Term 2?
(Yes, pizza will again be provided as koha!). Details will be provided in student notices.

- ○ Definitely!
- ○ Maybe, depending on the day.
- ○ No, thanks!

6. Do you have any other comments, questions, or concerns?

Appendix L.
Frequency Analysis of Survey Responses for *Reconnaissance* and *Evaluating* Phases

AWARENESS of Student Differences: *Reconnaissance* Teacher Views - Importance	Not important *n* (%)	Somewhat important *n* (%)	Neutral (don't care) *n* (%)	Important *n* (%)	Essential *n* (%)	Total *n*
I know individual student's interests	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	3
I relate my teaching and learning to individual student's interests	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	3
I know individual student's cultural backgrounds	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	3
I integrate cultural understanding into teaching and learning in a way that is inclusive, appropriate and relevant	0 (0.00%)	1 (33.33%)	0 (0.00%)	1 (33.33%)	1 (33.33%)	3
I am aware of individual student's intellectual or specific learning disabilities (dyslexia, ADHD, dyspraxia, etc.)	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	3
My teaching addresses learning disabilities in a way that provides students with attainable challenge and growth	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (100.00%)	0 (0.00%)	3
I know individual student's life situations and how these instances may impact learning	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (100.00%)	0 (0.00%)	3
I consider individual student's life situations in my classroom teaching and learning	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	3
I am aware of individual student's strengths and talents	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (100.00%)	0 (0.00%)	3
I address individual student's strengths and talents in teaching and learning so as to extend and challenge them	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (100.00%)	0 (0.00%)	3
I am aware of individual student's learning styles or preferences	0 (0.00%)	0 (0.00%)	1 (33.33%)	1 (33.33%)	1 (33.33%)	3
I incorporate individual student's learning styles or preferences into teaching and learning	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	3

AWARENESS of Student Differences: *Reconnaissance* Teacher Views - Usage	Never/ hardly ever do this *n* (%)	Sometimes/ have done a few times. *n* (%)	Frequently do this *n* (%)	Do intentionally and often *n* (%)	Not sure *n* (%)	Total *n*
I know individual student's interests	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	3
I relate my teaching and learning to individual student's interests	0 (0.00%)	3 (100.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3
I know individual student's cultural backgrounds	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	3
I integrate cultural understanding into teaching and learning in a way that is inclusive, appropriate and relevant	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	0 (0.00%)	3
I am aware of individual student's intellectual or specific learning disabilities (dyslexia, ADHD, dyspraxia, etc.)	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	3
My teaching addresses learning disabilities in a way that provides students with attainable challenge and growth	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	0 (0.00%)	3
I know individual student's life situations and how these instances may impact learning	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	3
I consider individual student's life situations in my classroom teaching and learning	0 (0.00%)	1 (33.33%)	1 (33.33%)	1 (33.33%)	0 (0.00%)	3
I am aware of individual student's strengths and talents	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (100.00%)	0 (0.00%)	3
I address individual student's strengths and talents in teaching and learning so as to extend and challenge them	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	0 (0.00%)	3
I am aware of individual student's learning styles or preferences	0 (0.00%)	1 (33.33%)	1 (33.33%)	0 (0.00%)	0 (0.00%)	3
I incorporate individual student's learning styles or preferences into teaching and learning	0 (0.00%)	3 (100.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3

CONTENT: *Reconnaissance* Teacher Views - Importance	Not important *n* (%)	Somewhat important *n* (%)	Neutral (don't care) *n* (%)	Important *n* (%)	Essential *n* (%)	Total *n*
Based on broad-based themes, issues and problems	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	3
In-depth and with breadth	0 (0.00%)	1 (33.33%)	0 (0.00%)	2 (66.67%)	0 (0.00%)	3
Planned, comprehensive, related and mutually reinforcing	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	3
Grounded on clearly articulated objectives: students are cognizant of what they should know, understand and be able to do	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	3
Gender balanced and inclusive	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (100.00%)	0 (0.00%)	3
Embedded with methods of inquiry: emulating the work of actual scientists	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	3
Engaged with science in real life contexts	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	3
Inclusive of variety, novelty, and diversity	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (100.00%)	0 (0.00%)	3
Marked by opportunities for complex and sophisticated thinking	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (100.00%)	0 (0.00%)	3
Inclusive of moral and/or ethical dimensions	0 (0.00%)	0 (0.00%)	1 (33.33%)	1 (33.33%)	1 (33.33%)	3
Inclusive of Māori dimensions that directly relate to real life contexts for students and their whānau	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	3

CONTENT: *Reconnaissance* Teacher Views - Usage	Never/ hardly ever do this *n* (%)	Sometimes/ have done a few times *n* (%)	Frequently do this *n* (%)	Do intentionally and often *n* (%)	Not sure *n* (%)	Total *n*
Based on broad-based themes, issues and problems	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	3
In-depth and with breadth	0 (0.00%)	1 (33.33%)	0 (0.00%)	2 (66.67%)	0 (0.00%)	3
Planned, comprehensive, related and mutually reinforcing	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (100.00%)	0 (0.00%)	3
Grounded on clearly articulated objectives: students are cognizant of what they should know, understand and be able to do	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	3
Gender balanced and inclusive	1 (33.33%)	0 (0.00%)	1 (33.33%)	1 (33.33%)	0 (0.00%)	3
Embedded with methods of inquiry: emulating the work of actual scientists	1 (33.33%)	2 (66.67%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3
Engaged with science in real life contexts	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	3
Inclusive of variety, novelty, and diversity	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	0 (0.00%)	3
Marked by opportunities for complex and sophisticated thinking	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	0 (0.00%)	3
Inclusive of moral and/or ethical dimensions	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	0 (0.00%)	3
Inclusive of Māori dimensions that directly relate to real life contexts for students and their whānau	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	0 (0.00%)	3

PROCESS: ***Reconnaissance*** **Teacher Views - Importance**	Not important *n* (%)	Somewhat important *n* (%)	Neutral (don't care) *n* (%)	Important *n* (%)	Essential *n* (%)	Total *n*
Pre-assess student readiness to adjust unit to meet individual needs	0 (0.00%)	0 (0.00%)	1 (33.33%)	1 (33.33%)	1 (33.33%)	3
Assess throughout unit to gauge individual understanding and modify class activities based upon results	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	3
Incorporate a variety of instruction modes other than a textbook	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	3
Vary pace of instruction based on individual learner needs	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	3
Incorporate learners in designing/selecting learning activities	0 (0.00%)	0 (0.00%)	1 (33.33%)	1 (33.33%)	1 (33.33%)	3
Provide a variety of support mechanisms (organisers, study guides, study buddies)	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	3
Adjust for diverse learner needs with scaffolding in learning activities	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	3
Adjust for diverse learner needs with tiering in learning activities	0 (0.00%)	0 (0.00%)	1 (33.33%)	1 (33.33%)	1 (33.33%)	3
Adjust for diverse learner needs with compacting in learning activities	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	3
Adjust for diverse learner needs with student choice in learning activities	0 (0.00%)	0 (0.00%)	1 (33.33%)	1 (33.33%)	1 (33.33%)	3
Provide tasks that require students to apply understanding	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	3
Provide tasks that require students to extend understanding	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	3
Assure all students must reach to challenge themselves to excel	0 (0.00%)	1 (33.33%)	0 (0.00%)	1 (33.33%)	1 (33.33%)	3
Support a variety of activities including group and individual work	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	3
Group students for learning activities based on student readiness	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (100.00%)	0 (0.00%)	3
Group students for learning activities based on individual student interests	0 (0.00%)	0 (0.00%)	1 (33.33%)	1 (33.33%)	1 (33.33%)	3
Allow for group composition changes based on activity	0 (0.00%)	0 (0.00%)	1 (33.33%)	1 (33.33%)	1 (33.33%)	3
Are open-ended, using discovery or problem-based learning strategies	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (100.00%)	0 (0.00%)	3
Stimulate higher levels of thinking (analysis, synthesis, and evaluation)	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	3
Include a "service" or opportunity to share outcomes for the good of others like the community or whānau	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	3
Are "real" - mirroring the roles, skills and expertise of scientists	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	3
Are designed to develop skills in time management	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (100.00%)	0 (0.00%)	3
Are designed to develop organisational skills	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (100.00%)	0 (0.00%)	3
Promote planning skills and decision-making processes	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (100.00%)	0 (0.00%)	3
Develop research strategies and skills	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	3
Utilise personal goal setting to direct and monitor growth	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	3
Are metacognitive - allowing students to reflect upon their own ways of thinking and learning	0 (0.00%)	0 (0.00%)	1 (33.33%)	1 (33.33%)	1 (33.33%)	3
Require students to gather and interpret data representations	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (100.00%)	0 (0.00%)	3
Encourage learners to use and critique evidence	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	3
Incorporate mentorship and/or involvement of professional scientists and content experts	0 (0.00%)	1 (33.33%)	0 (0.00%)	2 (66.67%)	0 (0.00%)	3
Reflect Tātaiako cultural competencies (ako, manaakitanga, tangata whenuatanga, whanaungatanga, wānanga)	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	3

PROCESS: ***Reconnaissance*** **Teacher Views - Usage**	Never/ hardly ever do this *n* (%)	Sometimes/ have done a few times *n* (%)	Frequently do this *n* (%)	Do intentionally and often *n* (%)	Not sure *n* (%)	Total *n*
Pre-assess student readiness to adjust unit to meet individual needs	1 (33.33%)	1 (33.33%)	1 (33.33%)	0 (0.00%)	0 (0.00%)	3
Assess throughout unit to gauge individual understanding and modify class activities based upon results	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	0 (0.00%)	3
Incorporate a variety of instruction modes other than a textbook	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	3
Vary pace of instruction based on individual learner needs	0 (0.00%)	1 (33.33%)	1 (33.33%)	1 (33.33%)	0 (0.00%)	3
Incorporate learners in designing/selecting learning activities	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	0 (0.00%)	3
Provide a variety of support mechanisms (organisers, study guides, study buddies)	0 (0.00%)	1 (33.33%)	1 (33.33%)	1 (33.33%)	0 (0.00%)	3
Adjust for diverse learner needs with scaffolding in learning activities	0 (0.00%)	1 (33.33%)	1 (33.33%)	1 (33.33%)	0 (0.00%)	3
Adjust for diverse learner needs with tiering in learning activities	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	0 (0.00%)	3
Adjust for diverse learner needs with compacting in learning activities	0 (0.00%)	2 (66.67%)	0 (0.00%)	0 (0.00%)	1 (33.33%)	3
Adjust for diverse learner needs with student choice in learning activities	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	0 (0.00%)	3
Provide tasks that require students to apply understanding	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	3
Provide tasks that require students to extend understanding	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	3
Assure all students must reach to challenge themselves to excel	0 (0.00%)	1 (33.33%)	1 (33.33%)	1 (33.33%)	0 (0.00%)	3
Support a variety of activities including group and individual work	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	3
Group students for learning activities based on student readiness	1 (33.33%)	0 (0.00%)	2 (66.67%)	0 (0.00%)	0 (0.00%)	3
Group students for learning activities based on individual student interests	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	0 (0.00%)	3
Allow for group composition changes based on activity	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	0 (0.00%)	3
Are open-ended, using discovery or problem-based learning strategies	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	0 (0.00%)	3
Stimulate higher levels of thinking (analysis, synthesis, and evaluation)	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	0 (0.00%)	3
Include a "service" or opportunity to share outcomes for the good of others like the community or whānau	2 (66.67%)	1 (33.33%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3
Are "real" - mirroring the roles, skills and expertise of scientists	2 (66.67%)	1 (33.33%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3
Are designed to develop skills in time management	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	0 (0.00%)	3
Are designed to develop organisational skills	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	3
Promote planning skills and decision-making processes	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	0 (0.00%)	3
Develop research strategies and skills	0 (0.00%)	0 (0.00%)	3 (100.00%)	0 (0.00%)	0 (0.00%)	3
Utilise personal goal setting to direct and monitor growth	1 (33.33%)	2 (66.67%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3
Are metacognitive - allowing students to reflect upon their own ways of thinking and learning	1 (33.33%)	2 (66.67%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	3
Require students to gather and interpret data representations	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	0 (0.00%)	3
Encourage learners to use and critique evidence	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	0 (0.00%)	3
Incorporate mentorship and/or involvement of professional scientists and content experts	1 (33.33%)	1 (33.33%)	1 (33.33%)	0 (0.00%)	0 (0.00%)	3
Reflect Tātaiako cultural competencies (ako, manaakitanga, tangata whenuatanga, whanaungatanga, wānanga)	1 (33.33%)	1 (33.33%)	0 (0.00%)	1 (33.33%)	0 (0.00%)	3

PRODUCTS: *Reconnaissance* Teacher Views - Importance	Not important *n* (%)	Somewhat important *n* (%)	Neutral (don't care) *n* (%)	Important *n* (%)	Essential *n* (%)	Total *n*
Have multiple modes of expression (written, visual, oral, multimedia,	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	3
Include a variety of formal and informal tasks	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (100.00%)	0 (0.00%)	3
Incorporate student choice to work alone, in pairs or small groups	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	3
Incorporate student interest and choice	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	3
Are evaluated appropriately and with specific criteria	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	3
Include student self-evaluation	0 (0.00%)	0 (0.00%)	1 (33.33%)	1 (33.33%)	1 (33.33%)	3
Are designed for an appropriate audience (not only the teacher)	0 (0.00%)	1 (33.33%)	0 (0.00%)	2 (66.67%)	0 (0.00%)	3
Are the result of "real" problems, challenging existing ideas and creating new ones	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	3
Are developed using new and real scientific techniques, materials and ide	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (100.00%)	0 (0.00%)	3
Enable students, like scientists, to present ideas in a variety of ways, including models, graphs, charts, diagrams and written texts	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (100.00%)	0 (0.00%)	3
Emulate real science: challenging students to connect new ideas to current and historical scientific knowledge	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	3
Emulate real science: challenging students to present their findings for peer review and/or debate	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	3
Are transformational of ideas, shifting students from the role of "consumers" to "producers" of knowledge	0 (0.00%)	0 (0.00%)	1 (33.33%)	2 (66.67%)	0.00%	3

PRODUCTS: *Reconnaissance* Teacher Views - Usage	Never/ hardly ever do this *n* (%)	Sometimes / have done a few times *n* (%)	Frequently do this *n* (%)	Do intentionally and often *n* (%)	Not sure *n* (%)	Total *n*
Have multiple modes of expression (written, visual, oral, multimedia, etc	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	0 (0.00%)	3
Include a variety of formal and informal tasks	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	3
Incorporate student choice to work alone, in pairs or small groups	0 (0.00%)	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	3
Incorporate student interest and choice	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	0 (0.00%)	3
Are evaluated appropriately and with specific criteria	0 (0.00%)	0 (0.00%)	0.00%	3 (100.00%)	0 (0.00%)	3
Include student self-evaluation	0 (0.00%)	100.00%	0.00%	0 (0.00%)	0 (0.00%)	3
Are designed for an appropriate audience (not only the teacher)	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	0 (0.00%)	3
Are the result of "real" problems, challenging existing ideas and creating new ones	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	0 (0.00%)	3
Are developed using new and real scientific techniques, materials and ide	0 (0.00%)	1 (33.33%)	2 (66.67%)	0 (0.00%)	0 (0.00%)	3
Enable students, like scientists, to present ideas in a variety of ways, including models, graphs, charts, diagrams and written texts	0 (0.00%)	0 (0.00%)	100.00%	0 (0.00%)	0 (0.00%)	3
Emulate real science: challenging students to connect new ideas to current and historical scientific knowledge	0 (0.00%)	2 (66.67%)	1 (33.33%)	0 (0.00%)	0 (0.00%)	3
Emulate real science: challenging students to present their findings for peer review and/or debate	1 (33.33%)	1 (33.33%)	1 (33.33%)	0 (0.00%)	0 (0.00%)	3
Are transformational of ideas, shifting students from the role of "consumers" to "producers" of knowledge	1 (33.33%)	1 (33.33%)	1 (33.33%)	0 (0.00%)	0 (0.00%)	3

Science Attitude: ***Reconnaissance*** **Student Views**	Disagree *n* (%)	Not Sure *n* (%)	Agree *n* (%)	Total *n*
I look forward to science lessons	9 (24.32%)	8 (21.62%)	20 (54.05%)	37
Science lessons are fun	9 (24.32%)	9 (24.32%)	19 (51.35%)	37
I enjoy the activities we do in science	5 (13.89%)	5 (13.89%)	26 (72.22%)	36
Science is one of the most interesting school subjects	9 (24.32%)	12 (32.43%)	16 (43.24%)	37
I want to find out more about the world in which we live	2 (5.41%)	8 (21.62%)	27 (72.97%)	37
Finding out about new things is important	1 (2.78%)	4 (11.11%)	31 (86.11%)	36
I enjoy science lessons at this college	11 (29.73%)	11 (29.73%)	15 (40.54%)	37
I like talking to my friends about what we do in science	11 (29.73%)	12 (32.43%)	14 (37.84%)	37
We should have more periods of science each week	12 (33.33%)	13 (36.11%)	11 (30.56%)	36
I feel satisfied after a science lesson	11 (29.73%)	17 (45.95%)	9 (24.32%)	37
Science is relevant to my life	4 (11.43%)	11 (31.43%)	20 (57.14%)	35
Science is relevant to my culture	10 (27.03%)	17 (45.95%)	10 (27.03%)	37
Science is relevant to my whānau	10 (27.78%)	15 (41.67%)	11 (30.56 %)	36

AWARENESS of Student Differences: ***Reconnaissance*** **Student Views - Importance**	Not important *n* (%)	Somewhat important *n* (%)	Neutral (don't care) *n* (%)	Important *n* (%)	Essential *n* (%)	Total *n*
My science teachers know what I am interested in	0 (0.00%)	6 (16.22%)	4 (10.81%)	20 (54.05%)	7 (18.92%)	37
My science teachers relate my interests to our classwork	3 (8.11%)	6 (16.22%)	7 (18.92%)	16 (43.24%)	5 (13.51%)	37
My science teachers know what I already know about the topic we are studying	2 (5.41%)	2 (5.41%)	5 (13.51%)	16 (43.24%)	12 (32.43%)	37
In science class I learn new things (not just relearn what I already know)	2 (5.41%)	4 (10.81%)	4 (10.81%)	12 (32.43%)	15 (40.54%	37
My science teachers know my cultural background	16 (43.24%)	5 (13.51%)	7 (18.92%)	10 (27.03%)	3 (8.11%)	37
My science teachers link my cultural background into our classwork	14 (37.84%)	7 (18.92%)	7 (18.92%)	5 (13.51%)	4 (10.81%)	37
My science teachers know the areas of my learning difficulties	3 (8.11%)	4 (10.81%)	3 (8.11%)	11 (29.73%)	16 (43.24%)	37
My science teachers address my learning disabilities in a way that supports me to grow/improve	4 (10.81%)	3 (8.11%)	4 (10.81%)	11 (29.73%)	15 (40.54%)	37
My science teachers know about my life outside of school	15 (40.54%)	10 (27.03%)	7 (27.03%)	3 (8.11%)	2 (5.41%)	37
My science teachers consider my life outside of school (commitments, whānau, etc.) in our classroom teaching	13 (35.14%)	7 (18.92%)	10 (27.03%)	6 (16.22%)	2 (2.70%)	37
My science teachers are aware of my individual strengths and talents	2 (5.41%)	8 (21.62%)	3 (8.11%)	16 (43.24%)	8 (21.62%)	37
My science teachers challenge me to grow and excel	4 (10.81%)	1 (2.70%)	3 (8.11%)	13 (35.14%)	16 (43.24%)	37
My science teachers know my learning styles or preferences	2 (5.41%)	6 (16.22%)	3 (8.11%)	19 (51.35%)	7 (18.92%)	37
My science teachers incorporate my learning styles or preferences into our teaching and learning	2 (5.41%)	6 (16.22%)	2 (5.41%)	20 (54.05%)	7 (18.92%)	37

AWARENESS of Student Differences: ***Reconnaissance*** **Student Views - Usage**	Never/ hardly ever *n* (%)	Sometimes *n* (%)	Frequently *n* (%)	Usually *n* (%)	Not sure *n* (%)	Total *n*
My science teachers know what I am interested in	3 (8.11%)	13 (35.14%)	9 (24.32%)	11 (29.73%)	1 (2.70%)	37
My science teachers relate my interests to our classwork	12 (32.43%)	14 (37.84%)	5 (13.51%)	4 (10.81%)	2 (5.41%)	37
My science teachers know what I already know about the topic we are studying	5 (13.51%)	8 (21.62%)	5 (13.51%)	13 (35.14%)	6 (16.22%)	37
In science class I learn new things (not just relearn what I already know)	4 (10.81%)	15 (40.54%)	5 (13.51%)	12 (32.43%)	1 (2.70%)	37
My science teachers know my cultural background	14 (37.84%)	14 (37.84%)	2 (5.41%)	2 (5.41%)	5 (13.51%)	37
My science teachers link my cultural background into our classwork	21 (56.76%)	10 (27.03%)	0 (0.00%)	2 (5.41%)	4 (10.81%)	37
My science teachers know the areas of my learning difficulties	8 (21.62%)	9 (24.32%)	14 (37.84%)	3 (8.11%)	3 (8.11%)	37
My science teachers address my learning disabilities in a way that supports me to grow/improve	11 (29.73%)	11 (29.73%)	8 (21.62%)	4 (10.81%)	3 (8.11%)	37
My science teachers know about my life outside of school	22 (59.46%)	7 (18.92%)	1 (2.70%)	3 (8.11%)	4 (10.81%)	37
My science teachers consider my life outside of school (commitments, whānau, etc.) in our classroom teaching	16 (43.24%)	9 (24.32%)	2 (5.41%)	3 (8.11%)	7 (18.92%)	37
My science teachers are aware of my individual strengths and talents	6 (16.22%)	7 (18.92%)	11 (29.73%)	10 (27.03%)	3 (8.11%)	37
My science teachers challenge me to grow and excel	6 (16.22%)	10 (27.03%)	9 (24.32%)	7 (18.92%)	5 (13.51%)	37
My science teachers know my learning styles or preferences	12 (32.43%)	6 (16.22%)	9 (24.32%)	7 (18.92%)	3 (8.11%)	37
My science teachers incorporate my learning styles or preferences into our teaching and learning	7 (19.44%)	12 (33.33%)	8 (22.22%)	5 (13.89%)	4 (11.11%)	36

CONTENT (The Topics We Learn in Science): ***Reconnaissance* Student Views - Importance**	Not important *n* (%)	Somewhat important *n* (%)	Neutral (don't care) *n* (%)	Important *n* (%)	Essential *n* (%)	Total *n*
Have big themes that deal with important issue, and problems	7 (18.92%)	2 (5.41%)	5 (13.51%)	17 (45.95%)	6 (16.22%)	37
Have a lot of variety but also allow us to study them in-depth	5 (13.51%)	4 (10.81%)	2 (5.41%)	15 (40.54%)	11 (29.73%)	37
Seem well-planned	3 (8.11%)	5 (13.51%)	1 (2.70%)	18 (48.65%)	10 (27.03%)	37
Have clear objectives: we are aware of what we need to know, understand and be able to do	2 (5.41%)	2 (5.41%)	6 (16.22%)	14 (37.84%)	13 (35.14%)	37
Encourage both genders (male and female) to succeed	3 (8.11%)	3 (8.11%)	2 (5.41%)	9 (24.32%)	20 (54.05%)	37
Encourage us to think and question like actual scientists	2 (5.41%)	2 (5.41%)	5 (13.51%)	17 (95.22%)	11 (29.73%)	37
Link to science in everyday life	2 (5.41%)	5 (13.51%)	10 (27.03%)	12 (32.43%)	8 (21.62%)	37
Provide opportunities for complex and sophisticated thinking	1 (2.70%)	3 (8.11%)	8 (21.62%)	21 (56.76%)	4 (10.81%)	37
Include moral and ethical issues and ideas	4 (10.81%)	7 (18.92%)	4 (10.81%)	21 (56.76%)	21 (56.76%)	37
Are inclusive of Māori Tātaiako (Kotahitanga – unity, Wānanga – sharing of knowledge) etc.	7 (18.92%)	6 (16.22%)	9 (24.32%)	12 (32.43%)	9 (24.32%)	37

CONTENT (The Topics We Learn in Science): ***Reconnaissance* Student Views - Usage**	Never/ hardly ever *n* (%)	Sometimes *n* (%)	Frequently *n* (%)	Usually *n* (%)	Not sure *n* (%)	Total *n*
Have big themes that deal with important issue, and problems	11 (29.73%)	9 (24.32%)	7 (18.92%)	6 (16.22%)	4 (10.81%)	37
Have a lot of variety but also allow us to study them in-depth	6 (16.22%)	8 (21.62%)	14 (37.84%)	8 (21.62%)	1 (2.70%)	37
Seem well-planned	4 (10.81%)	9 (24.32%)	10 (27.03%)	7 (18.92%)	7 (18.92%)	37
Have clear objectives: we are aware of what we need to know, understand and be able to do	6 (16.22%)	5 (13.51%)	12 (32.43%)	10 (27.03%)	4 (10.81%)	37
Encourage both genders (male and female) to succeed	5 (13.51%)	4 (10.81%)	9 (24.32%)	17 (45.95%)	2 (5.41%)	37
Encourage us to think and question like actual scientists	7 (18.92%)	9 (24.32%)	10 (27.03%)	10 (27.03%)	3 (8.11%)	37
Link to science in everyday life	9 (24.32%)	13 (35.14%)	6 (16.22%)	5 (13.51%)	4 (10.81%)	37
Provide opportunities for complex and sophisticated thinking	3 (8.11%)	13 (35.14%)	14 (37.51%)	5 (13.51%)	2 (5.41%)	37
Include moral and ethical issues and ideas	8 (21.62%)	11 (29.73%)	8 (21.62%)	5 (13.51%)	5 (13.51%)	37
Are inclusive of Māori Tātaiako (Kotahitanga – unity, Wānanga – sharing of knowledge) etc.	9 (24.32%)	11 (29.73%)	7 (18.92%)	4 (10.81%)	6 (16.22%)	37

PROCESS (The Processes We Use In Science): *Reconnaissance* Student Views - Importance	Not important *n* (%)	Somewhat important *n* (%)	Neutral (don't care) *n* (%)	Important *n* (%)	Essential *n* (%)	Total *n*
Include testing my knowledge to determine what I already know before we begin a new topic	1 (2.70%)	2 (5.41%)	4 (10.81%)	18 (48.65%)	12 (32.43%)	37
Involve checking my understanding as we study a topic and modifying class activities to help me learn what still	3 (8.11%)	5 (13.51%)	3 (8.11%)	17 (45.95%)	9 (24.32%)	37
Use many different ways to learn (not just reading from a book)	4 (10.81%)	0 (0.00%)	1 (2.70%)	18 (48.65%)	14 (37.84%)	37
Allow different people to work at different speeds	5 (13.51%)	2 (5.41%)	3 (8.11%)	16 (43.24%)	11 (29.73%)	37
Allow me to have choice in designing/selecting learning activities	6 (16.22%)	2 (5.41%)	4 (10.81%)	15 (40.54%)	10 (27.03%)	37
Use a variety of tools to support my learning (study guides, lab templates, partners)	4 (10.81%)	6 (16.22%)	3 (8.11%)	19 (51.35%)	5 (13.51%)	37
Provide tasks that require me to apply and extend my understanding	2 (5.41%)	7 (18.92%)	2 (5.41%)	18 (48.65%)	8 (21.62%)	37
Help me to challenge myself	3 (8.11%)	4 (10.81%)	4 (10.81%)	16 (43.24%)	10 (27.03%)	37
Support a variety of activities including group and individual work	3 (8.11%)	1 (2.70%)	2 (5.41%)	25 (67.57%)	6 (16.22%)	37
Allow us to be in different groups based on our interests and learning needs	2 (5.41%)	5 (13.51%)	3 (8.11%)	15 (40.54%)	12 (32.43%)	37
Allow us to work in different groups depending on the activity	3 (8.11%)	5 (13.51%)	3 (8.11%)	19 (51.35%)	7 (18.92%)	37
Challenge us to discover and problem-solve	4 (10.81%)	3 (8.11%)	0 (0.00%)	18 (48.65%)	12 (32.43%)	37
Stimulate us to think deeply (critically)	5 (13.51%)	6 (16.22%)	4 (10.81%)	15 (40.54%)	7 (18.92%)	37
Include a "service" component where we can share our information for the good of whānau and the community	4 (10.81%)	7 (18.92%)	10 (27.03%)	11 (29.73%)	5 (13.51%)	37 37
Are "real" science - mirroring the roles, skills and expertise of scientists	6 (16.22%)	8 (21.62%)	5 (13.51%)	13 (35.14%)	5 (13.51%)	37
Help me improve my time-management abilities	4 (10.81%)	4 (10.81%)	9 (24.32%)	16 (43.24%)	4 (10.81%)	37
Help me with my organisational skills	4 (10.81%)	5 (13.51%)	9 (24.32%)	14 (37.84%)	5 (13.51%)	37
Help me improve my planning and decision-making skills	2 (5.41%)	5 (13.51%)	5 (13.51%)	19 (51.35%)	6 (16.22%)	37
Help me grow in my ability to set, meet, and reflect on personal goals	3 (8.11%)	4 (10.81%)	4 (10.81%)	4 (10.81%)	7 (18.92%)	37
Help me improve my research skills	2 (5.41%)	3 (8.11%)	7 (18.92%)	19 (51.35%)	6 (16.22%)	37
Help me to reflect upon my own ways of thinking and learning	4 (10.81%)	4 (10.81%)	4 (10.81%)	20 (54.05%)	5 (13.51%)	37
Require me to gather and interpret data representations	5 (13.51%)	6 (16.22%)	1 (2.70%)	19 (51.35%)	6 (16.22%)	37
Encourage me to use and critique evidence	6 (16.22%)	7 (18.92%)	3 (8.11%)	17 (45.95	4 (10.81%)	37
Involve professional scientists and content experts	4 (10.81%)	5 (13.51%)	5 (13.51%)	16 (43.24%)	7 (18.92%)	37

PROCESS (The Processes We Use In Science): ***Reconnaissance*** **Student Views - Usage**	Never/ hardly ever *n* (%)	Sometimes *n* (%)	Frequently *n* (%)	Usually *n* (%)	Not sure *n* (%)	Total *n*
Include testing my knowledge to determine what I already know before we begin a new topic	4 (10.81%)	14 (37.84%)	10 (27.03%)	6 (16.22%)	3 (8.11%)	37
Involve checking my understanding as we study a topic and modifying class activities to help me learn what still	7 (18.92%)	16 (43.24%)	9 (24.32%)	5 (13.51%)	0 (0.00%)	37
Use many different ways to learn (not just reading from a book)	8 (21.62%)	10 (27.03%)	9 (24.32%)	7 (18.92%)	3 (8.11%)	37
Allow different people to work at different speeds	9 (24.32%)	8 (21.62%)	8 (21.62%)	9 (24.32%)	3 (8.11%)	37
Allow me to have choice in designing/selecting learning activities	12 (32.43%)	7 (18.92%)	10 (27.03%)	5 (13.51%)	3 (8.11%)	37
Use a variety of tools to support my learning (study guides, lab templates, partners)	6 (16.22%)	16 (43.24%)	8 (21.62%)	7 (18.92%)	0 (0.00%)	37
Provide tasks that require me to apply and extend my understanding	6 (16.22%)	12 (32.43%)	12 (32.43%)	6 (16.22%)	1 (2.70%)	37
Help me to challenge myself	9 (24.32%)	9 (24.32%)	9 (24.32%)	9 (24.32%)	1 (2.70%)	37
Support a variety of activities including group and individual work	4 (10.81%)	12 (32.43%)	11 (29.73%)	6 (16.22%)	4 (10.81%)	37
Allow us to be in different groups based on our interests and learning needs	7 (18.92%)	13 (35.14%)	5 (13.51%)	5 (13.51%)	7 (18.92%)	37
Allow us to work in different groups depending on the activity	10 (27.03%)	18 (48.65%)	4 (10.81%)	4 (10.81%)	1 (2.70%)	37
Challenge us to discover and problem-solve	8 (21.62%)	12 (32.43%)	8 (21.62%)	6 (16.22%)	3 (8.11%)	37
Stimulate us to think deeply (critically)	6 (16.22%)	15 (40.54%)	6 (16.22%)	5 (13.51%)	5 (13.51%)	37
Include a "service" component where we can share our information for the good of whānau and the community	7 (18.92%)	9 (24.32%)	6 (16.22%)	8 (21.62%)	7 (18.92%)	37
Are "real" science - mirroring the roles, skills and expertise of scientists	4 (10.81%)	12 (32.43%)	11 (29.73%)	4 (10.81%)	6 (16.22%)	37
Help me improve my time-management abilities	5 (13.51%)	11 (29.73%)	12 (32.43%)	6 (16.22%)	3 (8.11%)	37
Help me with my organisational skills	5 (13.51%)	12 (32.43%)	8 (21.62%)	10 (27.03%)	2 (5.41%)	37
Help me improve my planning and decision-making skills	4 (11.11%)	14 (38.89%)	5 (13.89%)	8 (22.22%)	5 (13.89%)	36
Help me grow in my ability to set, meet, and reflect on personal goals	6 (16.22%)	12 (32.43%)	7 (18.92%)	8 (21.62%)	4 (10.81%)	37
Help me improve my research skills	4 (10.81%)	12 (32.43%)	13 (35.14%)	6 (16.22%)	2 (5.41%)	37
Help me to reflect upon my own ways of thinking and learning	6 (16.22%)	10 (27.03%)	10 (27.03%)	8 (21.62%)	3 (8.11%)	37
Require me to gather and interpret data representations	6 (16.22%)	13 (35.14%)	5 (13.51%)	7 (18.92%)	6 (16.22%)	37
Encourage me to use and critique evidence	5 (13.51%)	13 (35.14%)	6 (16.22%)	6 (16.22%)	7 (18.92%)	37
Involve professional scientists and content experts	10 (27.03%)	11 (29.73%)	6 (16.22%)	5 (13.51%)	5 (13.51%)	37

PRODUCTS (The Products We Make in Science): ***Reconnaissance* Student Views - Importance**	Not important *n* (%)	Somewhat important *n* (%)	Neutral (don't care) *n* (%)	Important *n* (%)	Essential *n* (%)	Total *n*
Use a variety of options (tests, labs, projects, reports, etc.)	4 (10.81%)	2 (5.41%)	0 (0.00%)	19 (51.35%)	12 (32.43%)	37
Include both formal (end of topic) and informal (day to day) tasks	1 (2.70%)	7 (18.92%)	2 (5.41%)	19 (51.35%)	8 (21.62%)	37
Allow us to work alone, in pairs or small groups	3 (8.11%)	4 (10.81%)	3 (8.11%)	18 (48.65%)	9 (24.32%)	37
Allow me to choose how I show what I have learned based on my interests	3 (8.11%)	5 (13.51%)	4 (10.81%)	16 (43.24%)	9 (24.32%)	37
Have a marking schedule with clear expectations that is easy to follow and understand	5 (13.51%)	2 (5.41%)	7 (18.92%)	15 (40.54%)	8 (21.62%)	37
Are evaluated by both the teacher and myself	2 (5.41%)	6 (16.22%)	2 (5.41%)	21 (56.76%)	6 (16.22%)	37
Include more audiences than just the teacher and classmates	2 (5.41%)	5 (13.51%)	7 (18.92%)	19 (51.35%)	4 (10.81%)	37
Answer "real" science problems	4 (10.81%)	6 (16.22%)	4 (10.81%)	15 (40.54%)	8 (21.62%)	37
Challenge existing ideas	3 (8.33%)	2 (5.56%)	1 (2.78%)	20 (55.56%)	10 (27.78%)	36
Allow us to not just memorise but also create new knowledge	3 (8.11%)	5 (13.51%)	9 (24.32%)	13 (35.14%)	7 (18.92%)	37
Use new and real scientific techniques, materials and ideas	2 (5.41%)	3 (8.11%)	3 (8.11%)	19 (51.35%)	10 (27.03%)	37
Use real science, challenging us to connect our ideas to current and historical scientific knowledge	1 (2.70%)	3 (8.11%)	3 (8.11%)	24 (64.86%)	6 (16.22%)	37
Encourage us to present ideas in a variety of ways, including models, graphs, charts, diagrams and written texts	1 (2.70%)	4 (10.81%)	2 (5.41%)	16 (43.24%)	14 (37.84%)	37

PRODUCTS (The Products We Make in Science): ***Reconnaissance* Student Views - Usage**	Never/ hardly ever *n* (%)	Sometimes *n* (%)	Frequently *n* (%)	Usually *n* (%)	Not sure *n* (%)	Total *n*
Use a variety of options (tests, labs, projects, reports, etc.)	4 (10.81%)	7 (18.92%)	13 (35.14%)	10 (27.03%)	3 (8.11%)	37
Include both formal (end of topic) and informal (day to day) tasks	5 (13.51%)	15 (40.54%)	7 (18.92%)	8 (21.62%)	2 (5.41%)	37
Allow us to work alone, in pairs or small groups	5 (13.51%)	14 (37.84%)	10 (27.03%)	8 (21.62%)	0 (0.00%)	37
Allow me to choose how I show what I have learned based on my interests	6 (16.22%)	16 (43.24%)	5 (13.51%)	5 (13.51%)	5 (13.51%)	37
Have a marking schedule with clear expectations that is easy to follow and understand	4 (10.81%)	11 (29.73%)	7 (18.92%)	10 (27.03%)	10 (27.03%)	37
Are evaluated by both the teacher and myself	4 (10.81%)	14 (37.84%)	10 (27.03%)	6 (16.22%)	3 (8.11%)	37
Include more audiences than just the teacher and classmates	8 (21.62%)	14 (37.84%)	8 (21.62%)	3 (8.11%)	4 (10.81%)	37
Answer "real" science problems	7 (18.92%)	11 (29.73%)	13 (35.14%)	3 (8.11%)	3 (8.11%)	37
Challenge existing ideas	8 (21.62%)	9 (24.32%)	11 (29.73%)	4 (10.81%)	4 (10.81%)	37
Allow us to not just memorise but also create new knowledge	5 (13.51%)	11 (29.73%)	8 (21.62%)	12 (32.43%)	1 (2.70%)	37
Use new and real scientific techniques, materials and ideas	6 (16.22%)	6 (16.22%)	8 (21.62%)	7 (18.92%)	3 (8.11%)	37
Use real science, challenging us to connect our ideas to current and historical scientific knowledge	5 (13.51%)	12 (32.43%)	9 (24.32%)	8 (21.62%)	3 (8.11%)	37
Encourage us to present ideas in a variety of ways, including models, graphs, charts, diagrams and written texts	4 (10.81%)	11 (29.73%)	11 (29.73%)	7 (18.92%)	4 (10.81%)	37

Science Attitude: ***Evaluating* Pre/Post Student Views**		Disagree *n* (%)	Not sure *n* (%)	Agree *n* (%)	Total *n*
I look forward to science lessons	PRE	6 (21.43%)	8 (28.57%)	14 (50.00%)	28
	POST	3 (10.71%)	6 (21.43%)	19 (67.86%)	28
Science lessons are fun	PRE	6 (21.43%)	8 (28.57%)	14 (50.00%)	28
	POST	3 (10.71%)	7 (25.00%)	18 (64.29%)	28
I enjoy the activities we do in science	PRE	2 (7.41%)	5 (18.52%)	20 (74.07%)	27
	POST	2 (7.14%)	8 (28.57%)	18 (64.29%)	28
Science is one of the most interesting school subjects	PRE	6 (21.43%)	10 (35.71%)	12 (42.86%)	28
	POST	5 (17.86%)	12 (42.86%)	11 (39.29%)	28
I want to find out more about the world in which we live	PRE	2 (7.14%)	5 (17.86%)	21 (75.00%)	28
	POST	3 (10.71%)	9 (32.14%)	16 (57.14%)	28
Finding out about new things is important	PRE	1 (3.70%)	3 (11.11%)	23 (85.19%)	27
	POST	0 (0.00%)	4 (14.29%)	24 (85.71%)	28
I enjoy science lessons at this college	PRE	7 (25.00%)	9 (32.14%)	12 (42.86%)	28
	POST	4 (14.29%)	8 (28.57%)	16 (57.14%)	28
I like talking to my friends about what we do in science	PRE	8 (28.57%)	10 (35.71%)	10 (35.71%)	28
	POST	4 (14.29%)	15 (53.57%)	9 (32.14%)	28
We should have more periods of science each week	PRE	10 (37.04%)	10 (37.04%)	7 (25.93%)	27
	POST	13 (46.43%)	9 (32.14%)	6 (21.43%)	28
I feel satisfied after a science lesson	PRE	8 (28.57%)	13 (46.43%)	7 (25.00%)	28
	POST	5 (18.52%)	12 (44.44%)	10 (37.04%)	27
Science is relevant to my life	PRE	4 (15.38%)	8 (30.77%)	14 (53.85%)	26
	POST	4 (14.29%)	9 (32.14%)	15 (53.57%)	28
Science is relevant to my culture	PRE	8 (28.57%)	14 (50.00%)	6 (21.43%)	28
	POST	5 (17.86%)	19 (67.86%)	4 (14.29%)	28
Science is relevant to my whānau	PRE	10 (37.04%)	10 (37.04%)	7 (25.93%)	27
	POST	7 (25.00%)	21 (75.00%)	0 (0.00%)	28

AWARENESS of Student Differences: ***Evaluating*** **Pre/Post Student Views - Importance**		Not important *n* (%)	Somewhat important *n* (%)	Neutral (don't care) *n* (%)	Important *n* (%)	Essential *n* (%)	Total *n*
My science teachers know what I am interested in	PRE	0 (0.00%)	5 (17.86%)	4 (14.29%)	13 (46.43%)	6 (21.43%)	28
	POST	2 (7.14%)	7 (25.00%	5 (17.86%)	7 (25.00%)	7 (25.00%)	28
My science teachers relate my interests to our classwork	PRE	3 (10.71%)	4 (14.29%)	7 (25.00%)	10 (35.71%)	4 (14.29%)	28
	POST	4 (14.29%)	3 (10.71%)	6 (21.43%)	9 (32.14%)	6 (21.43%)	28
My science teachers know what I already know about the topic we are studying	PRE	1 (3.57%)	2 (7.14%)	5 (17.86%)	11 (39.29%)	9 (32.14%)	28
	POST	2 (7.14%)	3 (10.71%)	2 (7.14%)	14 (50.00%)	7 (25.00%)	28
In science class I learn new things (not just relearn what I already know)	PRE	2 (7.14%)	4 (14.29%)	3 (10.71%)	9 (32.14%)	10 (35.71%)	28
	POST	1 (3.57%)	1 (3.57%)	1 (3.57%)	12 (42.86%)	13 (46.43%)	28
My science teachers know my cultural background	PRE	10 (35.71%)	5 (17.86%)	5 (17.86%)	6 (21.43%)	2 (7.14%)	28
	POST	1 (3.57%)	1 (3.57%)	1 (3.57%)	12 (42.86%)	13 (46.43%)	28
My science teachers link my cultural background into our classwork	PRE	10 (35.71%)	6 (21.43%)	5 (17.86%)	4 (14.29%)	3 (10.71%)	28
	POST	10 (35.71%)	10 (35.71%)	21.43%	1 (3.57%)	1 (3.57%)	28
My science teachers know the areas of my learning difficulties	PRE	2 (7.14%)	4 (14.29%)	2 (7.14%)	8 (28.57%)	42.86%	28
	POST	3 (10.71%)	3 (10.71%)	2 (7.14%)	14 (50.00%)	6 (21.43%)	28
My science teachers address my learning disabilities in a way that supports me to grow/improve	PRE	3 (10.71%)	2 (7.14%)	3 (10.71%)	9 (32.14%)	11 (39.29%)	28
	POST	1 (3.57%)	5 (17.86%)	3 (10.71%)	13 (46.43%)	6 (21.43%)	28
My science teachers know about my life outside of school	PRE	12 (42.86%)	8 (28.57%)	6 (21.43%)	2 (7.14%)	0 (0.00%)	28
	POST	14 (50.00%)	4 (14.29%)	7 (25.00%)	0 (0.00%)	3 (10.71%)	28
My science teachers consider my life outside of school (commitments, whānau, etc.) in our classroom teaching	PRE	9 (32.14%)	6 (21.43%)	9 (32.14%)	3 (10.71%)	1 (3.57%)	28
	POST	7 (25.00%)	6 (21.43%)	9 (32.14%)	4 (14.29%)	2 (7.14%)	28
My science teachers are aware of my individual strengths and talents	PRE	2 (7.14%)	5 (17.86%)	3 (10.71%)	12 (42.86%)	6 (21.43%)	28
	POST	3 (10.71%)	3 (10.71%)	2 (7.14%)	15 (53.57%)	5 (17.86%)	28
My science teachers challenge me to grow and excel	PRE	3 (10.71%)	1 (3.57%)	2 (7.14%)	11 (39.29%)	11 (39.29%)	28
	POST	1 (3.57%)	5 (17.86%)	1 (3.57%)	12 (42.86%)	9 (32.14%)	28
My science teachers know my learning styles or preferences	PRE	2 (7.14%)	6 (21.43%)	3 (10.71%)	12 (42.86%)	5 (17.86%)	28
	POST	1 (3.57%)	7 (25.00%)	5 (17.86%)	9 (32.14%)	6 (21.43%)	28
My science teachers incorporate my learning styles or preferences into our teaching and learning	PRE	2 (7.14%)	4 (14.29%)	2 (7.14%)	15 (53.57%)	5 (17.86%)	28
	POST	3 (10.71%)	3 (10.71%)	5 (17.86%)	10 (35.71%)	7 (25.00%)	28

AWARENESS of Student Differences: ***Evaluating*** **Pre/Post Student Views - Usage**		Never/ hardly ever *n* (%)	Sometimes *n* (%)	Frequently *n* (%)	Usually *n* (%)	Not sure *n* (%)	Total *n*
My science teachers know what I am interested in	PRE	2 (7.14%)	10 (35.71%)	6 (21.43%)	9 (32.14%)	1 (3.57%)	28
	POST	4 (14.29%)	8 (28.57%)	8 (28.57%)	4 (14.29%)	4 (14.29%)	28
My science teachers relate my interests to our classwork	PRE	9 (32.14%)	9 (32.14%)	5 (17.86%)	4 (14.29%)	1 (3.57%)	28
	POST	6 (21.43%)	5 (17.86%)	7 (25.00%)	3 (10.71%)	7 (25.00%)	28
My science teachers know what I already know about the topic we are studying	PRE	4 (14.29%)	6 (21.43%)	5 (17.86%)	9 (32.14%)	4 (14.29%)	28
	POST	1 (3.57%)	12 (42.86%)	5 (17.86%)	7 (25.00%)	3 (10.71%)	28
In science class I learn new things (not just relearn what I already know)	PRE	1 (3.57%)	12 (42.86%)	4 (14.29%)	10 (35.71%)	1 (3.57%)	28
	POST	1 (3.57%)	8 (28.57%)	9 (32.14%)	9 (32.14%)	1 (3.57%)	28
My science teachers know my cultural background	PRE	10 (35.71%)	12 (42.86%)	2 (7.14%)	0 (0.00%)	4 (14.29%)	28
	POST	6 (21.43%)	8 (28.57%)	3 (10.71%)	3 (10.71%)	8 (28.57%)	28
My science teachers link my cultural background into our classwork	PRE	14 (50.00%)	9 (32.14%)	0 (0.00%)	1 (3.57%)	4 (14.29%)	28
	POST	10 (35.71%)	6 (21.43%)	5 (17.86%)	1 (3.57%)	6 (21.43%)	28
My science teachers know the areas of my learning difficulties	PRE	5 (17.86%)	8 (28.57%)	10 (35.71%)	2 (7.14%)	3 (10.71%)	28
	POST	2 (7.14%)	6 (21.43%)	11 (39.29%)	5 (17.86%)	4 (14.29%)	28
My science teachers address my learning disabilities in a way that supports me to grow/improve	PRE	7 (25.00%)	10 (35.71%)	5 (17.86%)	4 (14.29%)	2 (7.14%)	28
	POST	2 (7.14%)	8 (28.57%)	9 (32.14%)	3 (10.71%)	6 (21.43%)	28
My science teachers know about my life outside of school	PRE	18 (64.29%)	6 (21.43%)	0 (0.00%)	1 (3.57%)	3 (10.71%)	28
	POST	9 (32.14%)	5 (17.86%)	7 (25.00%)	1 (3.57%)	6 (21.43%)	28
My science teachers consider my life outside of school (commitments, whānau, etc.) in our classroom teaching	PRE	12 (42.86%)	6 (21.43%)	2 (7.14%)	3 (10.71%)	5 (17.86%)	28
	POST	7 (25.00%)	10 (35.71%)	4 (14.29%)	2 (7.14%)	5 (17.86%)	28
My science teachers are aware of my individual strengths and talents	PRE	4 (14.29%)	6 (21.43%)	8 (28.57%)	8 (28.57%)	2 (7.14%)	28
	POST	4 (14.29%)	8 (28.57%)	9 (32.14%)	5 (17.86%)	2 (7.14%)	28
My science teachers challenge me to grow and excel	PRE	3 (10.71%)	8 (28.57%)	8 (28.57%)	5 (17.86%)	4 (14.29%)	28
	POST	2 (7.14%)	6 (21.43%)	12 (42.86%)	6 (21.43%)	2 (7.14%)	28
My science teachers know my learning styles or preferences	PRE	7 (25.00%)	3 (10.71%)	8 (28.57%)	7 (25.00%)	3 (10.71%)	28
	POST	1 (3.57%)	11 (39.29%)	8 (28.57%)	4 (14.29%)	4 (14.29%)	28
My science teachers incorporate my learning styles or preferences into our teaching and learning	PRE	4 (14.81%)	8 (29.63%)	7 (25.93%)	4 (14.81%)	4 (14.81%)	27
	POST	4 (14.29%)	7 (25.00%)	6 (21.43%)	6 (21.43%)	5 (17.86%)	28

CONTENT (The Topics We Learn in Science): *Evaluating* Pre/Post Student Views - Importance		Not important *n* (%)	Somewhat important *n* (%)	Neutral (don't care) *n* (%)	Important *n* (%)	Essential *n* (%)	Total *n*
Have big themes that deal with important issue, and problems	PRE	5 (17.86%)	2 (7.14%)	5 (17.86%)	11 (39.29%)	5 (17.86%)	28
	POST	5 (17.86%)	4 (14.29%)	5 (17.86%)	12 (42.86%)	2 (7.14%)	28
Have a lot of variety but also allow us to study them in-depth	PRE	5 (17.86%)	3 (10.71%)	2 (7.14%)	10 (35.71%)	8 (28.57%)	28
	POST	2 (7.14%)	6 (21.43%)	4 (14.29%)	12 (42.86%)	4 (14.29%)	28
Seem well-planned	PRE	2 (7.14%)	5 (17.86%)	0 (0.00%)	14 (50%)	7 (25.00%)	28
	POST	1 (3.57%)	3 (10.71%)	3 (10.71%)	17 (60.71%)	4 (14.29%)	28
Have clear objectives: we are aware of what we need to know, understand and be able to do	PRE	1 (3.57%)	2 (7.14%)	5 (17.86%)	11 (39.29%)	9 (32.14%)	28
	POST	0 (0.00%)	6 (21.43%)	3 (10.71%)	13 (46.43%)	6 (21.43%)	28
Encourage both genders (male and female) to succeed	PRE	2 (7.14%)	2 (7.14%)	2 (7.14%)	7 (25.00%)	15 (53.57%)	28
	POST	1 (3.57%)	2 (7.14%)	0 (0.00%)	13 (46.43%)	12 (42.86%)	28
Encourage us to think and question like actual scientists	PRE	2 (7.14%)	2 (7.14%)	4 (14.29%)	13 (46.43%)	7 (25.00%)	28
	POST	1 (3.57%)	3 (10.71%)	7 (25.00%)	14 (50.00%)	3 (10.71%)	28
Link to science in everyday life	PRE	2 (7.14%)	5 (17.86%)	8 (28.57%)	8 (28.57%)	5 (17.86%)	28
	POST	4 (14.29%)	3 (10.71%)	5 (17.86%)	11 (39.29%)	5 (17.86%)	28
Provide opportunities for complex and sophisticated thinking	PRE	1 (3.57%)	2 (7.14%)	6 (21.43%)	15 (53.57%)	4 (14.29%)	28
	POST	2 (7.14%)	5 (17.86%)	7 (25.00%)	10 (35.71%)	4 (14.29%)	28
Include moral and ethical issues and ideas	PRE	3 (10.71%)	6 (21.43%)	3 (10.71%)	16 (57.14%)	7 (25.00%)	28
	POST	4 (14.29%)	8 (28.57%)	7 (25.00%)	8 (28.57%)	1 (3.57%)	28
Are inclusive of Māori Tātaiako (Kotahitanga – unity, Wānanga – sharing of knowledge) etc.	PRE	5 (17.86%)	5 (17.86%)	8 (28.57%)	8 (28.57%)	2 (7.14%)	28
	POST	8 (28.57%)	2 (7.14%)	10 (35.71%)	6 (21.43%)	2 (7.14%)	28

CONTENT (The Topics We Learn in Science): *Evaluating* Pre/Post Student Views - Usage		Never/ hardly ever *n* (%)	Sometimes *n* (%)	Frequently *n* (%)	Usually *n* (%)	Not sure *n* (%)	Total *n*
Have big themes that deal with important issue, and problems	PRE	8 (28.57%)	7 (25.00%)	6 (21.43%)	3 (10.71%)	4 (14.29%)	28
	POST	1 (3.57%)	9 (32.14%)	8 (28.57%)	6 (21.43%)	4 (14.29%)	28
Have a lot of variety but also allow us to study them in-depth	PRE	2 (7.14%)	7 (25.00%)	12 (42.86%)	6 (21.43%)	1 (3.57%)	28
	POST	1 (3.57%)	7 (25.00%)	13 (46.43%)	5 (17.86%)	2 (7.14%)	28
Seem well-planned	PRE	2 (7.14%)	7 (25.00%)	9 (32.14%)	5 (17.86%)	5 (17.86%)	28
	POST	1 (3.57%)	7 (25.00%)	8 (28.57%)	10 (35.71%)	2 (7.14%)	28
Have clear objectives: we are aware of what we need to know, understand and be able to do	PRE	4 (14.29%)	5 (17.86%)	9 (32.14%)	7 (25.00%)	3 (10.71%)	28
	POST	0 (0.00%)	6 (21.43%)	15 (53.57%)	6 (21.43%)	1 (3.57%)	28
Encourage both genders (male and female) to succeed	PRE	3 (10.71%)	4 (14.29%)	6 (21.43%)	14 (50.00%)	1 (3.57%)	28
	POST	0 (0.00%)	4 (14.29%)	11 (39.29%)	11 (39.29%)	2 (7.14%)	28
Encourage us to think and question like actual scientists	PRE	5 (17.86%)	4 (14.29%)	9 (32.14%)	7 (25.00%)	3 (10.71%)	28
	POST	4 (14.81%)	10 (37.04%)	7 (25.93%)	4 (14.81%)	2 (7.41%)	27
Link to science in everyday life	PRE	4 (14.29%)	12 (42.86%)	4 (14.29%)	4 (14.29%)	4 (14.29%)	28
	POST	3 (11.11%)	5 (18.52%)	12 (44.44%)	3 (11.11%)	4 (14.81%)	27
Provide opportunities for complex and sophisticated thinking	PRE	1 (3.57%)	9 (32.14%)	13 (46.43%)	3 (10.71%)	2 (7.14%)	28
	POST	2 (7.41%)	8 (29.63%)	11 (40.74%)	2 (7.41%)	4 (14.81%)	27
Include moral and ethical issues and ideas	PRE	4 (14.29%)	10 (35.71%)	6 (21.43%)	4 (14.29%)	4 (14.29%)	28
	POST	2 (7.41%)	10 (37.04%)	5 (18.52%)	3 (11.11%)	7 (25.93%)	27
Are inclusive of Māori Tātaiako (Kotahitanga – unity, Wānanga – sharing of knowledge) etc.	PRE	6 (21.43%)	9 (32.14%)	5 (17.86%)	3 (10.71%)	5 (17.86%)	28
	POST	7 (25.93%)	8 (29.63%)	7 (25.93%)	2 (7.41%)	3 (11.11%)	27

PROCESS (The Processes We Use In Science): *Evaluating* Pre/Post Student Views - Importance		Not important *n* (%)	Somewhat important *n* (%)	Neutral (don't care) *n* (%)	Important *n* (%)	Essential *n* (%)	Total *n*
Include testing my knowledge to determine what I already know before we begin a new topic	PRE	1 (3.57%)	2 (7.14%)	4 (14.29%)	13 (46.43%)	8 (28.57%)	28
	POST	3 (10.71%)	3 (10.71%)	2 (7.14%)	15 (53.57%)	5 (17.86%)	28
Involve checking my understanding as we study a topic and modifying class activities to help me learn what still	PRE	3 (10.71%)	5 (17.86%)	3 (10.71%)	13 (46.43%)	4 (14.29%)	28
	POST	0 (0.00%)	9 (32.14%)	4 (14.29%)	9 (32.14%)	6 (21.43%)	28
Use many different ways to learn (not just reading from a book)	PRE	3 (10.71%)	0 (0.00%)	1 (3.57%)	14 (50.00%)	10 (35.71%)	28
	POST	2 (7.14%)	5 (17.86%)	1 (3.57%)	11 (39.29%)	9 (32.14%)	28
Allow different people to work at different speeds	PRE	4 (14.29%)	2 (7.14%)	2 (7.14%)	12 (42.86%)	8 (28.57%)	28
	POST	2 (7.14%)	7 (25.00%)	2 (7.14%)	9 (32.14%)	8 (28.57%)	28
Allow me to have choice in designing/selecting learning activities	PRE	5 (17.86%)	1 (3.57%)	4 (14.29%)	10 (35.71%)	8 (28.57%)	28
	POST	2 (7.14%)	3 (10.71%)	6 (21.43%)	13 (46.43%)	4 (14.29%)	28
Use a variety of tools to support my learning (study guides, lab templates, partners)	PRE	3 (10.71%)	5 (17.86%)	3 (10.71%)	13 (46.43%)	4 (14.29%)	28
	POST	1 (3.57%)	6 (21.43%)	5 (17.86%)	11 (39.29%)	5 (17.86%)	28
Provide tasks that require me to apply and extend my understanding	PRE	2 (7.14%)	6 (21.43%)	1 (3.57%)	14 (50.00%)	5 (17.86%)	28
	POST	1 (3.57%)	8 (28.57%)	5 (17.86%)	10 (35.71%)	4 (14.29%)	28
Help me to challenge myself	PRE	3 (10.71%)	4 (14.29%)	4 (14.29%)	11 (39.29%)	6 (21.43%)	28
	POST	1 (3.57%)	4 (14.29%)	3 (10.71%)	13 (46.43%)	7 (25.00%)	28
Support a variety of activities including group and individual work	PRE	3 (10.71%)	1 (3.57%)	1 (3.57%)	19 (67.86%)	4 (14.29%)	28
	POST	1 (3.57%)	6 (21.43%)	3 (10.71%)	14 (50.00%)	4 (14.29%)	28
Allow us to be in different groups based on our interests and learning needs	PRE	2 (7.14%)	5 (17.86%)	2 (7.14%)	11 (39.29%)	8 (28.57%)	28
	POST	1 (3.57%)	5 (17.86%)	5 (17.86%)	15 (53.57%)	5 (17.86%)	28
Allow us to work in different groups depending on the activity	PRE	3 (10.71%)	4 (14.29%)	3 (10.71%)	14 (50.00%)	4 (14.29%)	28
	POST	2 (7.14%)	4 (14.29%)	5 (17.86%)	12 (42.86%)	5 (17.86%)	28
Challenge us to discover and problem-solve	PRE	4 (14.29%)	2 (7.14%)	0 (0.00%)	14 (50.00%)	8 (28.57%)	28
	POST	1 (3.57%)	4 (14.29%)	5 (17.86%)	12 (42.86%)	6 (21.43%)	28
Stimulate us to think deeply (critically)	PRE	4 (14.29%)	6 (21.43%)	4 (14.29%)	10 (35.71%)	4 (14.29%)	28
	POST	0 (0.00%)	5 (17.86%)	7 (25.00%)	14 (50.00%)	2 (7.14%)	28
Include a "service" component where we can share our information for the good of whānau and the community	PRE	3 (10.71%)	6 (21.43%)	9 (32.14%)	6 (21.43%)	4 (14.29%)	28
	POST	5 (17.86%)	8 (28.57%)	6 (21.43%)	8 (28.57%)	1 (3.57%)	28
Are "real" science - mirroring the roles, skills and expertise of scientists	PRE	5 (17.86%)	6 (21.43%)	5 (17.86%)	8 (28.57%)	4 (14.29%)	28
	POST	0 (0.00%)	8 (28.57%)	10 (35.71%)	8 (28.57%)	2 (7.14%)	28
Help me improve my time-management abilities	PRE	3 (10.71%)	4 (14.29%)	7 (25.00%)	11 (39.29%)	3 (10.71%)	28
	POST	1 (3.57%)	5 (17.86%)	5 (17.86%)	10 (35.71%)	7 (25.00%)	28
Help me with my organisational skills	PRE	3 (10.71%)	5 (17.86%)	7 (25.00%)	9 (32.14%)	4 (14.29%)	28
	POST	3 (10.71%)	5 (17.86%)	3 (10.71%)	9 (32.14%)	8 (28.57%)	28
Help me improve my planning and decision-making skills	PRE	2 (7.14%)	4 (14.29%)	4 (14.29%)	14 (50.00%)	4 (14.29%)	28
	POST	1 (3.57%)	6 (21.43%)	7 (25.00%)	12 (42.86%)	2 (7.14%)	28
Help me grow in my ability to set, meet, and reflect on personal goals	PRE	3 (10.71%)	3 (10.71%)	3 (10.71%)	13 (46.43%)	6 (21.43%)	28
	POST	2 (7.14%)	6 (21.43%)	3 (10.71%)	13 (46.43%)	4 (14.29%)	28
Help me improve my research skills	PRE	2 (7.14%)	3 (10.71%)	6 (21.43%)	13 (46.43%)	4 (14.29%)	28
	POST	0 (0.00%)	3 (10.71%)	5 (17.86%)	16 (57.14%)	4 (14.29%)	28
Help me to reflect upon my own ways of thinking and learning	PRE	4 (14.29%)	4 (14.29%)	2 (7.14%)	15 (53.57%)	3 (10.71%)	28
	POST	0 (0.00%)	7 (25.00%)	4 (14.29%)	14 (50.00%)	3 (10.71%)	28
Require me to gather and interpret data representations	PRE	5 (17.86%)	4 (14.29%)	1 (3.57%)	14 (50.00%)	4 (14.29%)	28
	POST	2 (7.14%)	5 (17.86%)	8 (28.57%)	11 (39.29%)	2 (7.14%)	28
Encourage me to use and critique evidence	PRE	6 (21.43%)	5 (17.86%)	3 (10.71%)	11 (39.29%)	3 (10.71%)	28
	POST	3 (10.71%)	7 (25.00%)	5 (17.86%)	8 (28.57%)	5 (17.86%)	28
Involve professional scientists and content experts	PRE	3 (10.71%)	5 (17.86%)	3 (10.71%)	12 (42.86%)	5 (17.86%)	28
	POST	2 (7.14%)	7 (25.00%)	3 (10.71%)	12 (42.86%)	4 (14.29%)	28

PROCESS (The Processes We Use In Science): ***Evaluating*** **Pre/Post Student Views - Usage**		Never/ hardly ever *n* (%)	Sometimes *n* (%)	Frequently *n* (%)	Usually *n* (%)	Not sure *n* (%)	Total *n*
Include testing my knowledge to determine what I already know before we begin a new topic	PRE	3 (10.71%)	12 (42.86%)	6 (21.43%)	5 (17.86%)	2 (7.14%)	28
	POST	3 (10.71%)	4 (14.29%)	6 (21.43%)	10 (35.71%)	5 (17.86%)	28
Involve checking my understanding as we study a topic and modifying class activities to help me learn what still	PRE	5 (17.86%)	13 (46.43%)	7 (25.00%)	3 (10.71%)	0 (0.00%)	28
	POST	1 (3.57%)	7 (25.00%)	8 (28.57%)	7 (25.00%)	5 (17.86%)	28
Use many different ways to learn (not just reading from a book)	PRE	6 (21.43%)	7 (25.00%)	7 (25.00%)	5 (17.86%)	3 (10.71%)	28
	POST	1 (3.57%)	6 (21.43%)	13 (46.43%)	7 (25.00%)	1 (3.57%)	28
Allow different people to work at different speeds	PRE	6 (21.43%)	8 (28.57%)	6 (21.43%)	6 (21.43%)	2 (7.14%)	28
	POST	1 (3.57%)	7 (25.00%)	11 (39.29%)	7 (25.00%)	2 (7.14%)	28
Allow me to have choice in designing/selecting learning activities	PRE	8 (28.57%)	5 (17.86%)	7 (25.00%)	5 (17.86%)	3 (10.71%)	28
	POST	2 (7.14%)	9 (32.14%)	10 (35.71%)	4 (14.29%)	3 (10.71%)	28
Use a variety of tools to support my learning (study guides, lab templates, partners)	PRE	3 (10.71%)	12 (42.86%)	8 (28.57%)	5 (17.86%)	0 (0.00%)	28
	POST	2 (7.14%)	6 (21.43%)	7 (25.00%)	9 (32.14%)	4 (14.29%)	28
Provide tasks that require me to apply and extend my understanding	PRE	3 (10.71%)	10 (35.71%)	10 (35.71%)	4 (14.29%)	1 (3.57%)	28
	POST	0 (0.00%)	11 (39.29%)	8 (28.57%)	5 (17.86%)	4 (14.29%)	28
Help me to challenge myself	PRE	5 (17.86%)	8 (28.57%)	8 (28.57%)	6 (21.43%)	1 (3.57%)	28
	POST	1 (3.57%)	6 (21.43%)	14 (50.00%)	2 (7.14%)	5 (17.86%)	28
Support a variety of activities including group and individual work	PRE	2 (7.14%)	11 (39.29%)	8 (28.57%)	4 (14.29%)	3 (10.71%)	28
	POST	2 (7.14%)	9 (32.14%)	7 (25.00%)	8 (28.57%)	2 (7.14%)	28
Allow us to be in different groups based on our interests and learning needs	PRE	4 (14.29%)	9 (32.14%)	4 (14.29%)	4 (14.29%)	7 (25.00%)	28
	POST	3 (10.71%)	8 (28.57%)	9 (32.14%)	5 (17.86%)	3 (10.71%)	28
Allow us to work in different groups depending on the activity	PRE	7 (25.00%)	14 (50.00%)	3 (10.71%)	3 (10.71%)	1 (3.57%)	28
	POST	3 (10.71%)	10 (35.71%)	10 (35.71%)	2 (7.14%)	3 (10.71%)	28
Challenge us to discover and problem-solve	PRE	6 (21.43%)	9 (32.14%)	7 (25.00%)	4 (14.29%)	2 (7.14%)	28
	POST	3 (10.71%)	8 (28.57%)	11 (39.29%)	4 (14.29%)	2 (7.14%)	28
Stimulate us to think deeply (critically)	PRE	3 (10.71%)	13 (46.43%)	6 (21.43%)	2 (7.14%)	4 (14.29%)	28
	POST	1 (3.57%)	10 (35.71%)	7 (25.00%)	7 (25.00%)	3 (10.71%)	28
Include a "service" component where we can share our information for the good of whānau and the community	PRE	5 (17.86%)	8 (28.57%)	3 (10.71%)	7 (25.00%)	5 (17.86%)	28
	POST	4 (14.29%)	5 (17.86%)	12 (42.86%)	2 (7.14%)	5 (17.86%)	28
Are "real" science - mirroring the roles, skills and expertise of scientists	PRE	3 (10.71%)	9 (32.14%)	9 (32.14%)	2 (7.14%)	5 (17.86%)	28
	POST	2 (7.14%)	8 (28.57%)	9 (32.14%)	3 (10.71%)	6 (21.43%)	28
Help me improve my time-management abilities	PRE	2 (7.14%)	10 (35.71%)	11 (39.29%)	3 (10.71%)	2 (7.14%)	28
	POST	2 (7.14%)	5 (17.86%)	11 (39.29%)	8 (28.57%)	2 (7.14%)	28
Help me with my organisational skills	PRE	3 (10.71%)	10 (35.71%)	6 (21.43%)	8 (28.57%)	1 (3.57%)	28
	POST	4 (14.29%)	10 (35.71%)	9 (32.14%)	3 (10.71%)	2 (7.14%)	28
Help me improve my planning and decision-making skills	PRE	1 (3.70%)	11 (40.74%)	5 (18.52%)	5 (18.52%)	5 (18.52%)	27
	POST	2 (7.14%)	7 (25.00%)	12 (42.86%)	2 (7.14%)	5 (17.86%)	28
Help me grow in my ability to set, meet, and reflect on personal goals	PRE	4 (14.29%)	9 (32.14%)	5 (17.86%)	6 (21.43%)	4 (14.29%)	28
	POST	2 (7.14%)	8 (28.57%)	8 (28.57%)	5 (17.86%)	5 (17.86%)	28
Help me improve my research skills	PRE	2 (7.14%)	9 (32.14%)	11 (39.29%)	4 (14.29%)	2 (7.14%)	28
	POST	1 (3.57%)	6 (21.43%)	11 (39.29%)	5 (17.86%)	5 (17.86%)	28
Help me to reflect upon my own ways of thinking and learning	PRE	2 (7.14%)	9 (32.14%)	8 (28.57%)	6 (21.43%)	3 (10.71%)	28
	POST	1 (3.57%)	8 (28.57%)	14 (50.00%)	3 (10.71%)	2 (7.14%)	28
Require me to gather and interpret data representations	PRE	4 (14.29%)	9 (32.14%)	5 (17.86%)	6 (21.43%)	4 (14.29%)	28
	POST	2 (7.14%)	4 (14.29%)	13 (46.43%)	4 (14.29%)	5 (17.86%)	28
Encourage me to use and critique evidence	PRE	3 (10.71%)	12 (42.86%)	5 (17.86%)	3 (10.71%)	5 (17.86%)	28
	POST	2 (7.14%)	4 (14.29%)	12 (42.86%)	3 (10.71%)	7 (25.00%)	28
Involve professional scientists and content experts	PRE	7 (25.00%)	9 (32.14%)	5 (17.86%)	3 (10.71%)	4 (14.29%)	28
	POST	3 (10.71%)	5 (17.86%)	10 (35.71%)	2 (7.14%)	8 (28.57%)	28

PRODUCTS (The Products We Make in Science): ***Evaluating*** **Pre/Post Student Views - Importance**		Not important *n* (%)	Somewhat important *n* (%)	Neutral (don't care) *n* (%)	Important *n* (%)	Essential *n* (%)	Total *n*
Use a variety of options (tests, labs, projects, reports, etc.)	PRE	3 (10.71%)	2 (7.14%)	0 (0.00%)	15 (53.57%)	8 (28.57%)	28
	POST	0 (0.00%)	3 (10.71%)	3 (10.71%)	15 (53.57%)	7 (25.00%)	28
	PRE	1 (3.57%)	5 (17.86%)	2 (7.14%)	14 (50.00%)	6 (21.43%)	28
Include both formal (end of topic) and informal (day to day) tasks	POST	3 (10.71%)	4 (14.29%)	8 (28.57%)	8 (28.57%)	5 (17.86%)	28
Allow us to work alone, in pairs or small groups	PRE	3 (10.71%)	4 (14.29%)	2 (7.14%)	11 (39.29%)	8 (28.57%)	28
	POST	0 (0.00%)	3 (10.71%)	4 (14.29%)	13 (46.43%)	8 (28.57%)	28
Allow me to choose how I show what I have learned based on my	PRE	2 (7.14%)	5 (17.86%)	4 (14.29%)	11 (39.29%)	6 (21.43%)	28
interests	POST	0 (0.00%)	7 (25.00%)	6 (21.43%)	9 (32.14%)	6 (21.43%)	28
Have a marking schedule with clear expectations that is easy to	PRE	4 (14.29%)	1 (3.57%)	7 (25.00%)	12 (42.86%)	4 (14.29%)	28
follow and understand	POST	0 (0.00%)	7 (25.00%)	3 (10.71%)	14 (50.00%)	4 (14.29%)	28
Are evaluated by both the teacher and myself	PRE	2 (7.14%)	4 (14.29%)	2 (7.14%)	15 (53.57%)	5 (17.86%)	28
	POST	1 (3.57%)	4 (14.29%)	4 (14.29%)	14 (50.00%)	5 (17.86%)	28
Include more audiences than just the teacher and classmates	PRE	2 (7.14%)	3 (10.71%)	6 (21.43%)	14 (50.00%)	3 (10.71%)	28
	POST	4 (14.29%)	3 (10.71%)	7 (25.00%)	9 (32.14%)	5 (17.86%)	28
Answer "real" science problems	PRE	3 (10.71%)	6 (21.43%)	4 (14.29%)	10 (35.71%)	5 (17.86%)	28
	POST	4 (14.29%)	5 (17.86%)	8 (28.57%)	8 (28.57%)	3 (10.71%)	28
Challenge existing ideas	PRE	3 (11.11%)	2 (7.41%)	1 (3.7%)	15 (55.56%)	6 (22.22%)	27
	POST	3 (10.71%)	9 (32.14%)	3 (10.71%)	10 (35.71%)	3 (10.71%)	28
	PRE	2 (7.14%)	5 (17.86%)	8 (28.57%)	8 (28.57%)	5 (17.86%)	28
Allow us to not just memorise but also create new knowledge	POST	0 (0.00%)	4 (14.29%)	6 (21.43%)	14 (50.00%)	4 (14.29%)	28
Use new and real scientific techniques, materials and ideas	PRE	2 (7.14%)	3 (10.71%)	2 (7.14%)	13 (46.43%)	8 (28.57%)	28
	POST	1 (3.57%)	4 (14.29%)	7 (25.00%)	10 (35.71%)	6 (21.43%)	28
Use real science, challenging us to connect our ideas to current	PRE	1 (3.57%)	3 (10.71%)	3 (10.71%)	16 (57.14%)	5 (17.86%)	28
and historical scientific knowledge	POST	3 (10.71%)	3 (10.71%)	7 (25.00%)	9 (32.14%)	6 (21.43%)	28
Encourage us to present ideas in a variety of ways, including	PRE	1 (3.57%)	3 (10.71%)	2 (7.14%)	11 (39.29%)	11 (39.29%)	28
models, graphs, charts, diagrams and written texts	POST	1 (3.57%)	6 (21.43%)	3 (10.71%)	15 (53.57%)	3 (10.71%)	28

PRODUCTS (The Products We Make in Science): ***Evaluating*** **Pre/Post Student Views - Usage**		Never/ hardly ever *n* (%)	Sometimes *n* (%)	Frequently *n* (%)	Usually *n* (%)	Not sure *n* (%)	Total *n*
Use a variety of options (tests, labs, projects, reports, etc.)	PRE	4 (14.29%)	6 (21.43%)	10 (35.71%)	7 (25.00%)	1 (3.57%)	28
	POST	0 (0.00%)	5 (17.86%)	10 (35.71%)	9 (32.14%)	4 (14.29%)	28
	PRE	3 (10.71%)	13 (46.43%)	5 (17.86%)	5 (17.86%)	2 (7.14%)	28
Include both formal (end of topic) and informal (day to day) tasks	POST	1 (3.57%)	4 (14.29%)	12 (42.86%)	7 (25.00%)	4 (14.29%)	28
Allow us to work alone, in pairs or small groups	PRE	3 (10.71%)	11 (39.29%)	7 (25.00%)	7 (25.00%)	0 (0.00%)	28
	POST	3 (10.71%)	0 (0.00%)	15 (53.57%)	8 (28.57%)	2 (7.14%)	28
Allow me to choose how I show what I have learned based on my	PRE	2 (7.14%)	14 (50.00%)	3 (10.71%)	4 (14.29%)	5 (17.86%)	28
interests	POST	4 (14.29%)	7 (25.00%)	9 (32.14%)	4 (14.29%)	4 (14.29%)	28
Have a marking schedule with clear expectations that is easy to	PRE	2 (7.14%)	9 (32.14%)	7 (25.00%)	7 (25.00%)	3 (10.71%)	28
follow and understand	POST	1 (3.57%)	6 (21.43%)	11 (39.29%)	7 (25.00%)	3 (10.71%)	28
Are evaluated by both the teacher and myself	PRE	3 (10.71%)	10 (35.71%)	9 (32.14%)	4 (14.29%)	2 (7.14%)	28
	POST	2 (7.14%)	6 (21.43%)	10 (35.71%)	5 (17.86%)	5 (17.86%)	28
Include more audiences than just the teacher and classmates	PRE	4 (14.29%)	12 (42.86%)	8 (28.57%)	2 (7.14%)	2 (7.14%)	28
	POST	4 (14.29%)	6 (21.43%)	9 (32.14%)	0 (0.00%)	9 (32.14%)	28
Answer "real" science problems	PRE	5 (17.86%)	9 (32.14%)	10 (35.71%)	1 (3.57%)	3 (10.71%)	28
	POST	2 (7.14%)	8 (28.57%)	8 (28.57%)	6 (21.43%)	4 (14.29%)	28
Challenge existing ideas	PRE	5 (18.52%)	9 (33.33%)	8 (29.63%)	3 (11.11%)	2 (7.41%)	27
	POST	4 (14.81%)	9 (33.33%)	7 (25.93%)	5 (18.52%)	2 (7.41%)	27
	PRE	2 (7.14%)	11 (39.29%)	5 (17.86%)	9 (32.14%)	1 (3.57%)	28
Allow us to not just memorise but also create new knowledge	POST	1 (3.57%)	6 (21.43%)	12 (42.86%)	3 (10.71%)	6 (21.43%)	28
Use new and real scientific techniques, materials and ideas	PRE	4 (14.29%)	12 (42.86%)	6 (21.43%)	3 (10.71%)	3 (10.71%)	28
	POST	3 (10.71%)	9 (32.14%)	9 (32.14%)	4 (14.29%)	3 (10.71%)	28
Use real science, challenging us to connect our ideas to current	PRE	3 (10.71%)	10 (35.71%)	6 (21.43%)	7 (25.00%)	2 (7.14%)	28
and historical scientific knowledge	POST	2 (7.14%)	4 (14.29%)	12 (42.86%)	4 (14.29%)	6 (21.43%)	28
Encourage us to present ideas in a variety of ways, including	PRE	2 (7.14%)	8 (28.57%)	10 (35.71%)	5 (17.86%)	3 (10.71%)	28
models, graphs, charts, diagrams and written texts	POST	3 (10.71%)	6 (21.43%)	14 (50.00%)	2 (7.14%)	3 (10.71%)	28

Appendix M.

Reconnaissance and *Evaluating* Teacher Observation Template

Differentiated Learning Classroom Observation Template

Teacher Code ____________________ Date ______________________________ Period (time of day) __________

Class Observed __________________ Year Group _______ Other Relevant Information _________________________

Unit Plan Provided? YES/NO Attached? YES/NO
Lesson Plan Provided YES/NO Attached? YES/NO

Observations of Teacher Responsiveness to Student Individuality	Observed	Not Observed	Not Relevant	Comments
Teacher relates teaching and learning to individual student's interests				
Teacher integrates cultural understanding into teaching and learning in a way that is inclusive, appropriate and relevant				
Teacher addresses learning disabilities in a way that provides students with attainable challenge and growth				
Teacher considers individual student's life situations in my classroom teaching and learning				
Teacher addresses individual student's strengths and talents in teaching and learning so as to extend and challenge them				
Teacher incorporates individual student's learning styles or preferences into teaching and learning				

The Content Taught in the Observed Classroom is	Observed	Not Observed	Not Relevant	Comments
Based on broad-based themes, issues and problems				
In-depth and with breadth				
Planned, comprehensive, related and mutually reinforcing				
Grounded on clearly articulated objectives: students are cognizant of what they should know, understand and be able to do				
Gender balanced and inclusive				
Embedded with methods of inquiry: emulating the work of actual scientists				
Engaged with science in real life contexts				
Inclusive of variety, novelty, and diversity				
Marked by opportunities for complex and sophisticated thinking				
Inclusive of moral and/or ethical dimensions				
Inclusive of Māori dimensions that directly relate to real life contexts for students and their whānau				

The <u>Processes</u> in the Observed Classroom	Observed	Not Observed	Not Relevant	Comments
Pre-assess student readiness to adjust unit to meet individual needs				
Assess throughout unit to gauge individual understanding and modify class activities based upon results				
Incorporate a variety of instruction modes other than a textbook				
Vary pace of instruction based on varying learner needs				
Incorporate learners in designing/selecting learning activities				
Provide a variety of support mechanisms (organizers, study guides, study buddies)				
Adjust for diverse learner needs with scaffolding in learning activities				
Adjust for diverse learner needs with tiering in learning activities				
Adjust for diverse learner needs with compacting in learning activities				
Adjust for diverse learner needs with student choice in learning activities				
Provide tasks that require students to apply understanding				
Provide tasks that require students to extend understanding				
Assure all students must reach to challenge themselves to excel				
Support a variety of activities including group and individual work				
Group students for learning activities based on student readiness				
Group students for learning activities based on individual student interests				
Group students for learning activities based on learning preferences				
Allow for group composition changes based on activity				
Are open-ended, using discovery or problem-based learning strategies				
Stimulate higher levels of thinking (analysis, synthesis, and evaluation)				
Include a "service" or opportunity to share outcomes for the good of others like the community or whānau				
Are "real" - mirroring the roles, skills and expertise of scientists				
Are designed to develop research skills, time management, organisational and planning abilities, decision making processes and personal goal setting				
Are metacognitive - allowing students to reflect upon their own ways of thinking and learning				
Require students to gather and interpret data representations				
Encourage learners to use and critique evidence				
Incorporate mentorship and/or involvement of professional scientists and content experts				
Reflect Tātaiako cultural competencies (ako, manaakitanga, tangata whenuatanga, whanaungatanga, wānanga)				

The **Products** of the Observed Class	Observed	Not Observed	Not Relevant	Comments
Have multiple modes of expression *(written, visual, oral, multimedia, etc.)*				
Include a variety of formal and informal tasks				
Incorporate student choice to work alone, in pairs or small groups				
Incorporate student interest and choice				
Are evaluated appropriately and with specific criteria including student self-evaluation				
Include student self-evaluation				
Are designed for an appropriate audience (not only the teacher)				
Are the result of "real" problems, challenging existing ideas and creating new ones				
Are developed using new and real scientific techniques, materials and ideas				
Enable students, like scientists, to present ideas in a variety of ways, including models, graphs, charts, diagrams and written texts				
Emulate real science: challenging students to connect new ideas to current and historical scientific knowledge				
Emulate real science: challenging students to present their findings for peer review and/or debate				
Are transformational of ideas, shifting students from the role of "consumers" to "producers" of knowledge				

Appendix N.
Reconnaissance Teacher Individual Interview Questions

Teacher Code _____________ **Date ____________**

Introduction
Thank you for agreeing to take part in this research into differentiation in secondary New Zealand science classrooms. The purpose of this interview is to gain information about your teaching background, beliefs, and current employment as well as allow you to expand upon classroom observations. Your audio and transcript answers will remain confidential.

Interview Questions

1. Gender ___________
2. Ethnicity (select all that apply)
   - Asian
   - European
   - Maori
   - Middle Eastern/Latin America/African
   - Pacifica
   - Other
3. Education or Practical Skills Background (please tick all that apply)
   - BA/BS specialising in ____________________________
   - Graduate Diploma in ____________________________
   - MA/MS specialising ____________________________
   - EdD/PhD specialising in ______________________
   - Other ____
4. In which country did your training primarily occur?
5. Why did you become a teacher?
6. Teaching Expertise.
   Which areas are your strengths in teaching? Explain.
   (Note: these strengths could stem from personality, interests, training or job experience.)
7. Number of years you have taught ______________
8. Number of years you have taught science ______________
9. Number of years you have taught at current school ______________

10. What is your primary goal as a teacher in the classroom?
    or
    Describe your educational philosophy.

11. Current subjects and levels taught?

12. Additional School Responsibilities? (HOF, Rugby Coach, etc)

13. On average, how many classes do you teach per day? ___________
14. On average, how many students do you have on your class roster per day? ___________
15. How much planning time is designated in your timetable on a typical day? ___________
16. How much additional planning, outside of the designated non-contact periods, do you typically do per day? ___________
17. How would you describe your school's management/leadership team's approach to differentiated instruction? (tick the one that applies most)
    _____ supports and encourages the use of differentiated instruction
    _____ encourages but does not provide support for differentiated instruction
    _____ neither encourages nor discourages differentiated instruction
    _____ discourages the use of differentiated instruction

18. What differentiation training have you had in the past 5 years? (circle all that apply)
    - Course from university
    - Teleconference or web conference
    - Within school professional development
    - Conference, meeting, or workshop (Please specify) ______________________________________
    - Other (Please specify) ____

19. List any other relevant differentiated instruction training you had prior to the past five years.

20. Let's discuss the observation data (what I observed in the classroom).

21. Thank you for participating in this interview. Do you have any additional questions, comments or ideas you would like to share?

If at any point in the research process you would like share any additional questions, comments or ideas, please do not hesitate to get in touch.

Survey questions modified in content and context to fit a New Zealand rural school from:

Kiley, D. (2011). *Differentiated Instruction in the Secondary Classroom: Anaysis of the Level of Implementation and Factors that Influence Practise.* (Doctoral dissertation). Western Michigan University, Kalamazoo. Available from: http://scholarworks.wmich.edu/cgi/viewcontent.cgi?article=1429&context=dissertations.

Appendix O.
Reconnaissance Student Focus Group Questions in Hui Setting

Date ________________ **Year Group _____________**

Introduction: I am interested in learning from you about how you describe yourself as a junior (years 9/10) college student. I am particularly interested in hearing you talk about your participation in your **science** classes and what you and your science teachers do to help you succeed. In fact, sometimes I may ask about specific events that I have observed. I am the only one who will know that the comments came from you. In order for me to can concentrate on what you are saying, I would like your permission to audio record our conversation. Again, these recorded comments will remain confidential. Is that OK with you?

Specific Questions:

1. Tell me about yourself.
   (Whānau, Iwi, in school and out of interests, passions, strengths, weaknesses).
   Note: Clarify as necessary and use prompts to obtain a fuller account of their ideas.

2. Do you feel that your science teachers know you as an individual—your strengths and weaknesses—and incorporate your interests into the classroom to help you learn? Explain.

3. Do you consider yourself to be a good science student? Why or why not?

4. What do you do that allows you to do well in science class?

5. What interferes with your ability to do well in science class?

6. What do your science teachers do that you find helpful for learning in the class?

7. What do you wish your science teachers would do to help you learn better?

8. Does every student in your class do the same thing?
Note: If yes, ask if they think that is a good idea and have them explain.
If no, ask how students differ in what they do and whether or not they think this helps promote effective learning for individual students and the class in general.

9. Educators use the term, differentiation, to talk about what they do to help each *unique* student succeed. If you were a teacher, how would you ***differentiate*** in your science class?

Apply Conversation with a Purpose Principles here:
- Probe areas of Environment, Content, Process, Product
- Resources to use: Initial Pre-Focus Group TOSRA and Student Voice Importance/Frequency Survey or introduce Kanevsky's Preferences for Differentiation Survey

10. What else would you would like me to know about you as a student and what a teacher might do to help challenge you to learn better that my previous questions did not cover?

Interview questions modified in context and content for rural Aotearoa New Zealand setting from the following resources:

Riley, T. (2011). Qualitative differentiation for gifted and talented students. In R. Moltzen (Ed), *Gifted and talented New Zealand perspectives, 3rd Edition (pp. 276-303). Malaysia: Pearson.*

Roe, M., F. (2009). *Differentiation in middle level literacy classrooms: The students speak.* Washington State University, Tri-Cities. Available from http://files.eric.ed.gov/fulltext/ED507336.pdf.

Appendix P.
Reconnaissance Whānau Focus Group Questions in Hui Setting

Date ________________ **Children's Year Group _____________**

Introduction:
This hui is all about your current experience and learning journey as the caregiver of a year 9 or 10 science student. It gives you a chance to share your version of what is happening in science at the school, what you would like your child to learn, how you would like them to learn it, and what you do to support your child's success. The results of this survey will be used to help the Science Department "differentiate," a term educators use to describe an awareness of and ability to meet individual student interests, strengths, and needs in the classroom.

In order for me to concentrate on what you are saying, I would like your permission to audio record our conversation. All recorded comments will be transcribed; to ensure confidentiality within the group, we ask that all participants sign a confidentiality statement before proceeding. I, too, will sign this statement. You have the right to ask me to turn off the recorder at any time, and to respond only to those questions of your choice. Do you have any questions?

Focus Group Questions:

1. Tell me about yourself, your whānau and your iwi affiliations, and your child. Feel free to include any other connections that you have with the local community and/or the school.
   Note: Clarify as necessary and use prompts to obtain a fuller account of their ideas.

2. What do you know about your child's science experience at the college?
   (Topics studied, products produced, skills gained, level of growth, engagement, interest, etc.)

3. What skills or behaviours does your child have that allow him/her to do well in science?

4. What interferes with his/her ability to do well in science?

5. What does your child's science teacher do that you find helpful for your child's learning?

6. What do you wish your child's science teacher would do to help your child learn better?

7. How does the school's science department support your child's learning?

   A) Do they know your child's strengths and weaknesses and factor this into teaching and learning? Please explain.

   B) Do they incorporate your child's interests into teaching and learning? If so, how?

   C) Is this something that is important to you? Why or why not?

8. How do teachers show they care about your child's learning?

   A) What do they do or say to show they care about your child's learning?

   B) Is this something that is important to you? Why or why not?

9. "Not everyone learns the same things, in the same ways at the same time" (Riley, p. 276). Educators use the term differentiation to describe an awareness of and ability to meet individual student interests, strengths, and needs in the classroom. What type of modifications would work best for your child?

10. If you were a teacher, how would you *differentiate* in your science class?

Potential prompts here include:
Applying Conversation with a Purpose Principles through

- *Probing Areas of Environment, Content, Process, Product*
- *Expanding upon Initial Pre-Focus Group TOSRA and Student Voice Importance/Frequency Survey*
- *Kanevsky's Preferences for Differentiation Survey*

11. How are whānau and/or the community currently involved in helping to make science engaging and relevant to real life for years 9/10 (Pre-NCEA Level Classes) at school?

12. In what ways do the board, principal and/or teachers encourage culture (Māori and otherwise) in the school?

13. What else do you think would be important for the research project to know about you, your whānau, or community?

14. What could the science department and/or school do to help challenge your child to learn better that my previous questions did not cover?

Interview questions modified in context and content for rural Aotearoa New Zealand setting from the following resources:

Riley, T. (2011). Qualitative differentiation for gifted and talented students. In R. Moltzen (Ed), *Gifted and talented New Zealand perspectives, 3rd Edition (pp. 276-303). Malaysia: Pearson.*

Roe, M., F. (2009). *Differentiation in middle level literacy classrooms: The students speak.* Washington State University, Tri-Cities. Available from http://files.eric.ed.gov/fulltext/ED507336.pdf.

Appendix Q.
Differentiation Resources Shared in *Planning* Phase - Collaborative Session 1

Kanevsky's Brief Descriptions of Content, Process and Product Differentiation Strategies

CONTENT
Abstractness: The content focuses on abstract concepts, themes, generalizations and theories, not concrete facts. It addresses ideas that have a wide range of applicability.
Complexity: Complex content focuses on the interconnections among concepts, principles, generalizations and theories. It is usually interdisciplinary.
Extracurricular topics: The content includes ideas and content areas not taught in the regular curriculum in any grade. It may include the student's interests.
Lives & living: The content involves the study of creative, productive people (living or dead), their motivations, social characteristics, challenges and career paths.
Organization for learning value: The content of an entire unit addresses a broad, interdisciplinary theme (like "systems" or "patterns") rather than small, sequential bits of information.
Real life topics: The content addresses issues, controversies, problems or provocative questions inspired by students' interests, experiences, questions and concerns. Students may need help focusing, analysing and/or defining their topic or questions.
Self-selected content: The student chooses the content. Some will need help choosing and reducing their interests to topics that are manageable.

PROCESS
Complex thinking: Emphasize learning processes (verbs) that stress the use, rather than acquisition of information (higher level thinking, critical thinking, creative thinking, etc.).
Expert methods of inquiry: Learning with and about methods used by experts in a discipline.
Group Interaction: Students collaborate with peers who have similar abilities and share their passions in order to enhance their social and leadership skills, learn perspective-taking and become more empathetic.
Individual Pursuits: Individual projects on which students work relatively independently but with the support of a teacher or mentor available as needed.
Inquiry-based: Inductive reasoning processes are used to discover patterns, underlying principles and generalizations. Students take greater responsibility for their learning than in deductive learning experiences.
Open-endedness: Activities involve open-ended questions, activities, projects and methods. These have no predetermined correct outcome. They are provocative, stimulating students to think broadly.
Pacing: Students learn at a pace commensurate with their ability to go quickly through or deeply into content. Examples include pretesting, "compacting", or "telescoping" curriculum, or other forms of acceleration.
Reasoning & reflection: Students explain their conclusions and the reasoning that led to them as well as the metacognitive aspects of their thinking. They are encouraged to evaluate both the process and products of their own and others' thinking.
Self-selected process: Students choose the ways they will learn whenever possible. Some may need assistance identifying their preferences or following through on their choices.
Variety: A range of methods of thinking and feeling involved in learning by using different types of problems, resources and technologies.

PRODUCT
Authentic audiences: Results of the learning activity should be shared with real and appropriate audiences to the greatest extent possible. This may involve the scientific community, the city council, a government agency, art critic, etc. Feedback & assessment: Products should be assessed using real, predetermined procedures and criteria, and, as often as possible, by a member or members of the real audience for the product. Students should also be encouraged or required to self-evaluate their products using the same criteria.
Self-selected product: The student chooses an appropriate format for the product that reflects what was learned. Students' interests, strengths, and prior experiences may influence these choices. Teachers may need to provide assistance in the selection and development of the product.
Transformations: The results of the learning process should represent a "conversion of known information into new entities—changes in meaning, significance, use, interpretation, mood, sensory qualities, or shape" (Guilford, 1967).
Variety: Students learn about and use different types of production techniques and media throughout the school year or term. They should also learn how to select an appropriate format for the audience and content

Differentiated Process Student Options

Student Directions:

In this list you'll find words that describe ways to learn. Circle all the ways you like.

adapt
analyse
appraise
arbitrate
argue
arrange
assess
award
blend
calculate
change
choose
classify
collect
combine
compare
compile
compose
conclude
construct
contrast
count
create
critique
debate
decide
deconstruct
defend
define
demonstrate
describe
design
determine
develop
diagram
differentiate
discuss
disprove
dispute
dissect
distinguish
divide
elaborate
estimate
evaluate
explain
form
formulate
grade
group
hypothesise
illustrate
imagine
improve
integrate
interpret
invent
investigate
judge
justify
mediate
modify
monitor
organize
outline
paint
plan
predict
prepare
prioritise
produce
propose
rank
rate
recite
recommend
relate
revise
rewrite
role-play
separate
simplify
solve
sort
strengthen
summarise
support
survey
synthesise
test
track
verify
weigh

YOUR CORNER:
Are there other ways you'd like to learn? List them here:

Differentiated Product Student Options

This is a list of things you [as a student] might make to show what you've learned. Circle all that look good to you.

3-D model
advertisement
amusement park ride
app
article for magazine
autobiography
banner
bibliography
biography
blog
blueprint
book
book review
broadcast
brochure
business plan
campaign
cartoon
carving
celebration
chapter
chart
club
collage
collection
comic strip
commentary
commercial
computer graphic
computer program
conference
presentation
critical analysis
dance
debate
demonstration
diagram
dialogue
diary
dictionary
display
documentary
drawing
editorial
equation
essay
evaluation checklist
event
exhibit
experiment
fabric
fact file
fairy tale
film or filmstrip
flag
floor plan
flow chart

flyer
game
game show
geometric model
graph
graphic
graphic organizer
greeting card
group presentation
guide
handbook
histogram
illusion
illustrated story
illustration
instructions
Internet search
interview
invention
investigation
itinerary
jewellery
jingle
joke
journal
learning centre
lecture
lesson
letter
limerick
log
logic puzzle
logo
machine
magazine
magazine article
manual
map
mask
matrix
menu
metaphor
mobile
mock trial
model
monologue
montage
monument
motto
multimedia
presentation
mural
museum
music
mystery
narrative
news report

newsletter
newspaper
newspaper article
novel
oral report
outline
painting
pamphlet
panel discussion
pantomime
party
pattern
performance
personal experience
photo album
photo essay
picture story
pie chart
plan
play
podcast
poem
political cartoon
pop-up book
portfolio
position paper
poster
prediction
presentation
program
puppet
puppet show
puzzle
questionnaire
quilt
radio show
rap
rebus story
recipe
recitation
re-enactment
relief map
report
research report
review
role play
samples
scenario
science fiction story
scrapbook
script
sculpture
self-portrait
seminar
sermon
service project
short story

sign
simulation
sketch
skit
slide show
sociogram
song
speech
spreadsheet
story
summary
survey
table
tape-recording
telegram
textbook
theory
time capsule
timeline
trademark
travelogue
triptych
TV show
Venn diagram
video game
wall hanging
weaving
webpage
website
wiki

YOUR CORNER:
Please list other ways you'd like to show what you know.

Reprinted with author permission from Kanevsky's (2013) *Preferences for Learning Survey* possibilitiesforlearning.com (p. 13).

Prompts for Creating Open-Ended Tasks That Stimulate High Levels of Thinking

The prompts below are offered as starting points for creating open-ended learning experiences of any size in any subject:

- How would ________ be different if ________ ?
- How is ________ like _________? [forced relationship]
- What do you think _________ will be like in 50/100/?? years?
- If you were a _________, how would you help (an inventor, a person in history or a character in a story or novel)?
- The answer is _______. What might the question have been?
- How would you feel if _________? Explain what would make you feel that way.
- What would it be like to _________?
- What would your life be like if _________?
- Design a _________ to __________.
- Create a _________ to promote __________.
- What is one possible solution to (some problem or dilemma in history, your school or
- literature)?
- List all of the ways to _________ that __________ might __________.
- Identify/list every __________ you can think up/imagine.
- Generate a list of any/all/every ....
- Write all of the ways you can think of to ....
- List any advantages/disadvantages to ....
- Give (some number) of reasons __________ might ___________.
- Develop a way to ....
- Design a house/home/habitat for ....
- What if ...?
- What would happen if ...?
- Where could ...?
- When might ...?
- Describe what would happen if you combined a/the __________ with a/the __________.
- What (some number) questions would you (most) like to ask ___________?
- What makes ___________ (worthwhile, risky, scary, funny....)?
- Invent a __________ to help ___________ with ___________.
- What are the implications/consequences of ____________ for ____________?
- Think of another way ____________ could have ___________'d.
- Prepare a (product) to convince ___________ to ___________.
- Why do you think ____________?
- Come up with new and unusual uses for ___________.
- Describe (some number) of changes you would recommend/make to __________ to make it/them (funnier, faster, more beautiful, more efficient, more economical, more impressive, better for young children, suitable for adults, suitable for people with visual impairments....).
  Put them in a polite letter to _________.

Reprinted with author permission from *The Tool Kit for High End Differentiation*
Kanevsky, 2013, Appendices, p. 10.

Subject: Science
Grade Level: Middle School
Topic: Genetics

Titanic Mystery

Purpose Statement

This culminating assessment is designed to assess students' knowledge of genetics and their understanding of traits of inheritance.

Knowledge, Skills and Dispositions

Students will demonstrate their

- understanding of genotype and phenotype
- understanding of dominant and recessive traits
- ability to analyze DNA strands of protein

Related Outcomes and/or Standards

- The student will investigate and understand that organisms reproduce and transmit genetic information to new generations. Key concepts include:
  ⇒ the role of DNA; and
  ⇒ characteristics that can and cannot be inherited.
- The student will investigate and understand common mechanisms of inheritance and protein synthesis. Key concepts include:
  ⇒ prediction of inheritance of traits based on the laws of heredity;
  ⇒ events involved in the construction of proteins; and
  ⇒ exploration of the impact of DNA technologies.
- The student will investigate and understand the basis for modern classification systems. Key concepts include:
  ⇒ comparison of DNA sequences in organisms; and
  ⇒ examination of protein similarities and differences among organisms.

Prerequisites:

The student should be able to:

- identify peptides and nucleotides
- create Punnett squares
- identify dominant, hybrid, and recessive genes and the phenotype
- understand related vocabulary, such as phenotype and genotype

Funding for the development of these tasks was supported under the Educational Research and Development Centers, PR/Award Number R206R50001, as administered by the Office of Educational Research and Improvement, U.S. Department of Education.

Appendix R.
Draft of Differentiated Unit: Responsive to *Reconnaissance* Input

Years 9 & 10 Science Unit Planning: Human Body Systems

Notes: Year 9 have not studied the digestive system
Survey – topics interested in, health issues interested in, knowledge/experience of any health issues due to themselves/family members
Time: 1 term (10 weeks) allow 1 week for revision & 1 week for assessment (prefer to spread throughout unit)

Start: Introduction/Seating Plan
Lab Rules (leave equipment briefing/use of Bunsens/refresher on measurements etc. till required)
Books + equipment
Expectations – homework
Title page

---

1. Blood
   Components – function & application
   White cells – infections
   Red cells – oxygen/iron/energy
   Platelets – clotting, haemophilia
   Veins/arteries (spurt, dark red/
   capillaries –photos/slides/microscopes
   Pulse rate

2. Heart
   Structure/names/function
   Dissection
   Heart attack/blood pressure

3. Circulatory System
   Body network
   Experiment – exercise/caffeine heart rate, graphs

4. Skeleton
   Cow bones
   Broken bones

5. Respiratory system – lungs
   Structure/function
   Lung capacity experiment
   Dissection
   Smoking

6. Muscles/Joints
   Anatomy/function
   Dissection
   Practicals/models
   "Ripped" torn muscles – warm up/cool down – visit from gym instructor, sports coach
   Flexibility
   Achilles tendon
   Ligaments – knee scans

7. Excretion – kidneys
   Dialysis – Jonah Lomu
   Dissection

8. Research Project

Other topics if time: Skin cancer, hypothermia/hyperthermia, diabetes (blood sugar – maybe better suited to studying with year 9 digestive system)

Check: Term length
Number lesson/week
Classes usually lost during 1st term

Appendix S.
Prior Knowledge Survey as Implemented in the *Acting* Phase

Name **Date** 3 feb 2016

Year 9 & 10 Science Start of Year Survey

1. When you are not in science (or at school), what are you most likely to be doing (hobbies, sports, interests)?

   Netball
   horse riding

2. What did you enjoy about science in previous years? Why?

   Not last year but Yr8 + Yr7 was fun we learnt cool facts and experiment

3. What didn't you like about science? Why?

   The teacher Not fun didnt learn much

4. Do you learn best by working in a group, with a partner or by yourself? Explain.

   Partner or by myself

5. Please rank from 1-10 in order of how you prefer to learn (1 being your favourite, 10, your least favourite; if you hate it, put an "x" by it instead)?

   9 reading books
   6 watching videos or TV
   4 googling/using the internet
   5 drawing pictures
   5 taking notes
   9 listening to the teacher
   7 filling in worksheets
   10 doing practical activities
   7 class discussions
   ______ other: ______________

6. List a goal for yourself for science this year.

   To work on my theory

7. What should your science teachers know about you to help you succeed this year?

   I ask lots of questions to figure answer out

*Survey sample includes responses from Year 9 non-Māori female;
the student's name has been removed for confidentiality purposes.

8. Do you have any future career(s) in mind yet, and if so what are they?

Equestrian or Photogropher

9. Have you ever broken a bone? If so, which one(s) & how?

No none

10. A) What dissections have you done in the past?

a cows eye ~~Kind of~~

B) Are you interested in more dissections? YES/**(NO)**

C) Are you OK being the "surgeon"? YES/**(NO)**

11. Have you, or any family members suffered from any disease or health issue that you don't mind telling us about? If so, what? (eg. heart attack, stroke, kidney transplant)

Pop had a heart attack and health problems.

I was supposed to be a dwarf with clubfoot with retardation. But did not happen

12. Do you have an interest in any particular health issues? *eg. getting fit for rugby season, asthma, allergies, Zika virus, stretching muscles, stopping smoking, knee dislocations?*

No thanks mrs V

SCIENCE ROCKS!

13. If you rated your current knowledge of human body systems on a scale of 1-10 (1 = know nothing, 10 = I'm an expert) what would it be?

7 or 8

14. Have you ever done a first aid course?

No but my mum has

15. Would you be interested in doing a first aid course this year in science?

Yes

16. List 2 things you'd like to study/learn about human body systems and health:

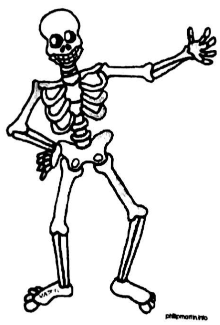
digestion + organs

17. Do you have any connections to guest speakers who may have interesting jobs/stories about human body systems and health issues? Please share.

No

18. Any questions/comments on the topic of human body systems and health issues?

No I like it



Appendix T.

Research Update for Participating Students and Whānau

Massey University, Institute of Education — January, 2016

Junior Science Differentiated Teaching & Learning Research Update 1

Phase 1 Results Summary

Participant Overview (Data Sources)

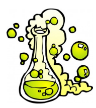
ONLINE SURVEYS
students n = 39 (26 yr 8; 13 yr 9)
teachers n = 3
(100% yr 9/10 teachers)

FOCUS GROUPS
students n = 27 (14 yr 9; 13 yr 8)
whānau (n= 8)

CLASSROOM OBSERVATIONS & INDIVIDUAL INTERVIEWS
teachers (n=3)
(100% yr 9/10 teachers)

MAIN FINDINGS

1. **Shared Perceptions**
   Teachers & students voiced similar perspectives on the majority of survey questions regarding classroom happenings
2. **Greater relevance needed!**
   All stakeholders agree that it is unrealistic to cater to each child every day; however, students and whānau resoundingly agree that greater relevance of material learnt to everyday life, community and cultural context, as well as skills needed for students' future NCEA studies and career (i.e. differentiation in content).
3. **More choice & practical please!**
   Students and whānau called for greater variety in how content is learnt (differentiation in process/product); students of both genders and year groups both voiced their enjoyment of practical work and a desire for 'real' experimentation, not just the demonstration type.
4. **Pre-Post Assessment crucial to maximise growth**
   Assessing and responding to students' pre-existing knowledge and interests is viewed as an essential learning strategy by all students and whānau, but especially those talented in the sciences



Teachers' Response: Summer 2016

Year 9 and 10 science teachers met over the summer to map out a curriculum committed to increasing relevance, choice, hands-on opportunities, and pre-post assessment. This including working with the Maths department to facilitate greater integration of maths/science skills such as graphing, statistical analysis etc. The first of these "integrated" units will be implemented in term one and focuses on human body systems. If you or your child has expertise in this area that you're willing to share, please get in touch!

Other Changes in 2016

Year 9/10 science classes will be combined and streamed based on previous science and maths achievement. Differentiation will still occur in all classes, but the top stream will be held to a more rigorous academic standard.

What's next?

Teachers will implement the first revised Year9/10 unit in Term 1, 2016. Focus group students will have the opportunity to share feedback to teachers both during (about halfway) and after the implantation. Watch for whānau focus group invitations in March and April!

Want to know more?

In depth Phase 1 results, a preview of the 2016 Year 9/10 science & maths unit overview, and ongoing research developments are available on the research website sweetasscience.weebly.com or through contacting Ms. V. directly at cvanderzwaag@gmail.com.

Appendix U.
Overview of Implemented Years 9/10 Differentiated Human Body Systems Unit

Science Unit Plan: Staying Alive! (Body Systems)

aka. Reaching (become a) superhuman training… your superhuman potential

Year(s)	Level(s)	Duration	Teacher	Classroom
9 & 10	***5***	*8 weeks*		

Select the Strand(s) and the Achievement Objectives to be assessed

■ **Nature of Science**
☐ **Understanding about science** Students will understand that scientists' investigations are informed by current scientific theories and aim to collect adequate evidence that is interpreted through processes of logical argument. ☐ **Investigating in science** Students will develop and carry out investigations that use a variety of approaches. Variables will be considered and logical and justifiable conclusions drawn. ■ **Communicating in science** Students will use a wider range of science vocabulary, symbols, and conventions (including diagrams, graphs, and formulae). They will apply their understandings of science to evaluate both popular and scientific texts (including visual and numerical literacy). ☐ **Participating and contributing** Students will develop an understanding of socio-scientific issues by gathering relevant scientific information in order to draw evidence-based conclusions and take action where appropriate.
■ **Living World**
■ **Life processes** Describe the organisation of life at the cellular level. Identify the key structural features and functions involved in the life processes of plants and animals. ☐ **Ecology** Investigate the interdependence of living things in an ecosystem. ☐ **Evolution** Describe the basic processes by which genetic information is passed from one generation to the next.
☐ Planet earth and Beyond
☐ **Earth cycles** Investigate the processes that shape and change the surface features of planet Earth. ☐ **Astronomical cycles** Investigate the cycles that result from interactions between the Sun, Moon, and Earth. ☐ **Interacting cycles** Investigate how natural events and human actions can affect conditions for living on Earth.
☐ **Physical World**
☐ **Physical enquiry and physical concepts** Identify physical phenomena and concepts associated with everyday situations involving movement, forces, electricity and magnetism, light, waves, sound, and heat. ☐ **Using physics** Explore issues related to technological applications of physics.

☐ Material World		
☐ **Properties of materials** Investigate the physical and chemical properties of a range of substances and relate these to their appropriate and safe use, both in their personal and the wider environment. ☐ **Chemical reactions** Explore and investigate chemical reactions of a range of substances and identify these occurring in everyday situations. ☐ **Particles** Develop an understanding of the nuclear atom model. Distinguish between elements and compounds at the particle level and represent them in appropriate ways.		
Big Ideas • To know and understand basic functional human anatomy, organs involving the circulatory, respiratory, skeletal and excretory systems. Taught in context of keeping healthy. • What can go wrong, why, and how to treat • Digestive system to be covered in another year. • Try to include any Māori treatments/natural/herbal/homeopathic remedies (speaker?)		
Specific Learning Outcomes *By the end of this unit, students will be able to:* • *Identify the major body organs and know the functions of these organs* • *Identify the major bones on a human skeleton* • *Investigate how hinge joints function* • *Distinguish between ligament, cartilage and tendon in a synovial joint* • *Identify the major features and functions of the human circulatory system* • *Distinguish the similarities and differences between arteries, veins and capillaries* • *Label the features of the human heart* • *Understand the basic process of respiration* • *Identify the parts of lungs and explain how we breathe* • *Identify the parts of the excretory system* • *Understand the importance of a healthy lifestyle on our heart, lungs and kidneys* • *Communicate information on a disease related to a body system* • *Identify common diseases and research their cause, symptoms and treatment*		
Key Competencies focus: (Select only those being focussed on)		☐ managing self ☐ relating to others ☐ participating and contributing ☐ thinking ☐ using language, symbols, and texts.
Literacy (L):		
Differentiated Learning (DL)		
Teaching and Learning Activities by lesson		
Lesson 1	Seating Plan, Lab rules/expectations, Stationary required Revision of lab use/equipment use e.g. bunsens, measurement refresher as required Survey – attitude to science, previous knowledge of topic, experience of health issues of self/family members, special interest areas Introduce topic/learning outcomes Title Page	

Lesson 2	Circulatory System – Blood Components – function & application White cells – fight infection, antibodies Red cells – oxygen/iron/energy Platelets – clotting/haemophilia Plasma Use photos/microscopes/slides? Photos blood cells laptop Cells/Organs Notes p55 Science Basics + pictures p63 blood cells droplet diagram + spider diagram
Lesson 3	Blood vessels Difference between veins (valves) & arteries (pressure, spurting, colour), capillaries "Circulation" handout Artery/vein models P172/173 Scipad "Blood" handout BrainPop "Circulatory system" quiz/activities How to stop bleeding Soft tissue injuries e.g. bruising, how occur & how to treat Could discuss mosquito borne virus currently being transmitted in Brazil, implications for Olympic athletes Allergies – over active immune system
Lesson 4	Heart Structure/names/function Direction of flow Handout 'heart outline', label (laptop has picture) P174/175 Scipad (labelled diagram + flow), model p178 Model heart Heart photo laptop Heart notes p64 Science Basics www.hybridmedicalanimation.com/anim_bloodflow.html (beating heart animation) www.brainpop.com/health/bodysystems/heart (video/quiz/activity: label heart/flow diagram/vocab) Heart worksheet – diagram + table Ppt – Organ Systems – heart
Lesson 5	Heart worksheet in computer room
Lesson 6	Heart dissection (maybe do this later after a bit of revision) Assess practical – label parts, assess with oral discussion. Pairs/groups – some students may be squeamish
Lesson 7	Body circulatory system map/diagram P177 Scipad diagram BrainPop "Circulatory system" – video/quiz Worksheet – label circulatory system Circulatory system wordfind Pulse rate – how to measure, what it is Worksheets (2) pulse rate & exercise graph Blood pressure Heart attacks, strokes
Lesson 8	Practical Effect of exercise (or caffeine (drugs)) on heart rate (need accurate monitoring equipment for heart rate) Collect data in groups

Lesson 9	Analyse data Draw graphs & write up experiment using correct scientific method Exercise for 6 mins heart rate 60-200bpm Individual assessment May need a practice graphing session as a class
Lesson 10	Respiratory System – Lungs Structure/function/how inhale & exhale Make models Notes Science Basics p57 Scipad p182, 183, 184 Lungs handout model, wordfind BrainPop
Lesson 11	Lung capacity experiment? Or similar (asthma/peak flow bar graph) Breathing rate practical - graph Lung worksheet in computer room
Lesson 12	Lung dissection if can get some lungs
Lesson 13	Smoking – pictures/photos Reasons why not to smoke Questionnaire – answers Draw cigarette + labels Draw body – labels of damage P62 Science Basics P185 Scipad
Lesson 14	Skeletal System Make models Skeleton handout – cut & paste Label p163, 164, 165 Scipad Circulation handout – sentences Bones crossword Scipad (mandible, femur) Word match – beginning, middle, end www.neok12.com – label the diagram game – skeleton Lesson 1 skeleton 471KB Use cow bones – name bone Broken bones – how to identify a broken bone, treatment
Lesson 15	Muscles/joints Anatomy/function: Joints; attach muscles, work as levers Types: Hinge e.g. arm, knee Ball & socket e.g. hip, shoulder Pivot Muscles notes sheet Scipad p166, 167, 170 Muscles & Levers folder – ppt lesson 1 – Skeleton & Joints – ball & socket, hinge - Ppt – Joints – all joints - Ppt – Movement at joints – revision on bones/joints Muscle & joints pictures 198KB Joints ppt – 1018KB Movement at joints – 3635KB BrainPop muscles, joints video/quiz Models. Importance of flexibility. Define "ripped" torn muscles. How tendons work. Ligaments. Knee scans

Lesson 16	Dissection – pigs trotters, chicken legs
Lesson 17	Visit to (or from) gym instructor/Pilates/sports coach. Warm up & cool down techniques. Stretching.
Lesson 18	Excretory system Kidneys, structure & function Ppt – Organ Systems – kidneys P68 Science Basics BrainPop Dialysis Jonah Lomu
Lesson 19	Kidney dissection
Lesson 20	Book computer room Individual research project, give research template. Can give early on to allow students to prepare. Students to choose topic, make a brochure? Could be a case study on a famous person or relative
Lesson 21	Research
Lesson 22	Research
Lesson 23	Revision – concept map linking ideas & keywords
Lesson ?	Visit by nurse? Or Red Cross 'student first aid certificate' can be assessed
Lesson ?	If time, could also cover skin cancer, hypo/hyperthermia (may be covered in an English 'survival' unit)
Final Lesson	Written assessment
Resources	
Assessment Schedule Small assessments throughout unit	
Unit Evaluation	

Appendix V.

Increasing Product Variety: *Acting* Individual Research Assignment

Years 9 and 10 Science
Body Systems Assignment

Select a condition/disease that affects one of the body systems we have discussed in class.

Systems discussed: cardiovascular, excretory, skeletal, respiratory, muscular.

Examples of diseases/conditions (there are many more): arthritis, heart attack, kidney failure, broken bone, lung cancer, emphysema, torn Achilles, tendon.

<u>Individually produce a poster about your chosen disease/condition</u>

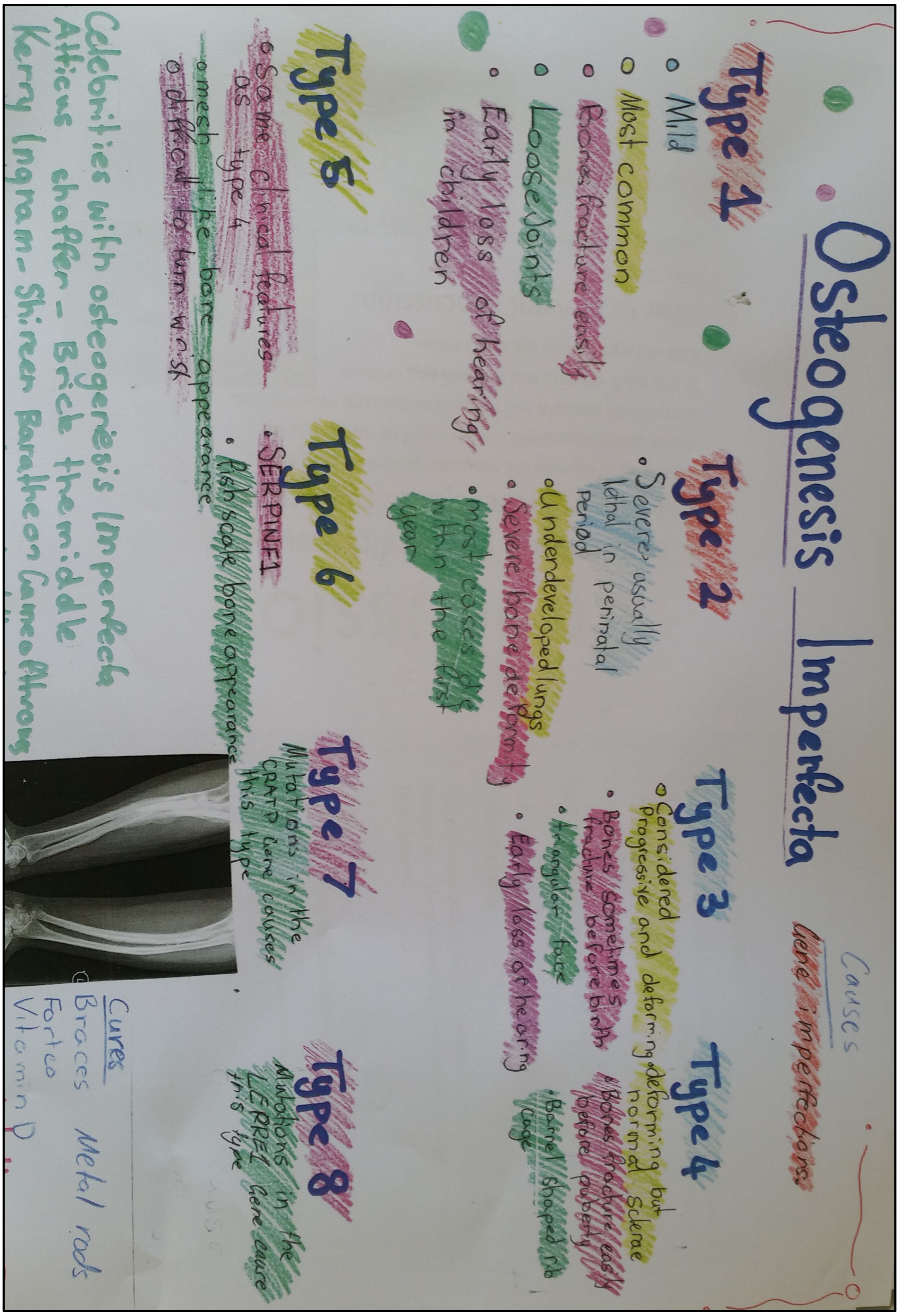
Your poster will have the following information:

- CAUSES
- SYMPTOMS
- MODERN TREATMENT

For extra marks:

- Any alternative therapies/treatments that may be used
- Celebrities/famous people/people you know that have suffered from this condition/disease

Appendix W.
Student Work Sample for Individual Research Assignment



Appendix X.
Increasing Product Variety: *Acting* Hands-On Exercise Practical

Name: ____

Year 10 Science - Exercise Practical

Aim

- To see if pulse rate changes after exercise.
- To see how fast an individual recovers after exercise and then determine who is the fittest in the class

Hypothesis

____

____

____

Method

- Select individuals; one to exercise, one to measure pulse rate, one to record results
- Take base pulse rate per minute, record
- Exercise e.g. Run 2 laps of field
- Record pulse rate immediately after completion of exercise, and then in 30-second intervals for 5 minutes.
- Equipment: Recording sheet, pen/pencil, timer/stopwatch/phone, heart rate monitor
- How to measure pulse rate:
- Find pulse in wrist, sit quietly & count the beats in 1 minute (or count the beats in 15secs and then multiply by 4)
- Alternative is to use a heart rate monitor

Results

Name of student exercising ______________________________

Student measuring pulse rate ____________________________

Student recording results ________________________________

TIME	Resting	After Exercise 0 min	30 secs	1 min	1:30	2 min	2:30	3 min	3:30	4 min	4:30	5 min
PULSE RATE (bpm)												

Graph

Line graph: Minutes after exercise vs. Pulse rate (heartbeats per minute)

Please attach your graph to this worksheet

You will also be provided with another graph comparing the pulse rates of all individuals who exercised.

Conclusion (should include analysis of both graphs as well as any improvements that could be made to your experiment)

____

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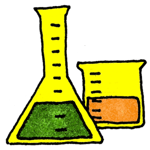
Appendix Y.
Evaluating Student Focus Group Questions in Hui Setting

Student Focus Group *Evaluating* Hui **Date ______** **Year Group _____**

Introduction



Since we last met, the science teachers reviewed your feedback from the 2015 focus groups as well as input from the online surveys and classroom observations. They met over the summer to map out a 2016 curriculum committed to increasing relevance, choice, hands-on opportunities, and pre/post assessment. This second (and final!) focus group is created to evaluate the recent changes. It gives you a chance to share your version of what is happening in the 2016 years 9 and 10 science classrooms. The results of this focus group will be used to help the Science Department teachers continue to adjust and modify what and how they teach.

As before, I am the only one who will know that the comments came from you. In order for me to concentrate on what you are saying, I would like your permission to audio record our conversation. Again, these recorded comments will remain confidential. Is that OK with you?

Questions Schedule

1. Please describe any changes (good and/or bad) to your science experience that you have noticed since we last met in Term 4.

2. Years 9 and 10 science teachers met over the summer to map out a curriculum committed to increasing relevance, choice, hands-on opportunities, and pre/post assessment.

   A) How have the science teachers increased the *relevance* of:

      1) What they teach (Content)?

      2) How they teach (Process)?

      3) How they assess your learning (Product)?

   B) How have science teachers increased the level of student *choice* in:

      1) What you study (Content)?

      2) How you learn (Process)?

      3) How you demonstrate what you have learnt (Product)?

   C) How are science teachers incorporating *hands-on* learning into their teaching this year?

   D) How are science teachers incorporating your:

      1) Prior knowledge into science lessons this year?

      2) Interests into science lessons this year

3. Does every student in your class do the same thing? Explain. (Content/Process/Product)

4. Do you now consider yourself to be a talented science student? Why or why not?

5. How has the school's science department supported your learning in 2016?
(i.e. Addressing individual strengths and weaknesses and factoring this into teaching and learning?)

6. Some of you mentioned that you are unsure as to whether your ideas from Term 4 have been incorporated into the classroom or not. Please explain using specific example(s).

7. What do you wish your science teacher would do to help you learn better?

8. Online surveys revealed enjoyment of science classes is higher in 2016, yet the number of students that said it was one the most interesting school subjects dropped. Why do you think this is?

9. Online survey responses to whether you are learning heaps more/a bit more/the same/less/much less in 2016 are quite varied. Can you explain your response?

10. Similarly, responses to the amount of challenge that occurs in the 2016 science classroom are varied.   Can you explain your response/opinion use specific example(s)?

11. Although science teachers have tried to make what you study more relevant, the 2016 student online surveys show the number of students who believe that science is relevant to their lives, culture, and whānau has dropped substantially since December. Any ideas on why this might be?

12. How are whānau and/or the community currently involved in helping to make science engaging and relevant to real life for years 9/10 (Pre-NCEA Level Classes) at school?

13. How should whānau and/or the community be involved in helping to make science engaging and relevant to real life for years 9/10 (Pre-NCEA Level Classes) at school?

14. What else would you would like me to know about you as a student and what a teacher might do to help challenge you to learn better that my previous questions did not cover?

15. Guided discussion on issues arising from survey open-ended responses:
    - Why did you "like the body systems" topic?
    - How can teachers better encourage to you "want to do something and to learn about the topic?"
    - How do you suggest teachers incorporate "more fun and challenging things to do?"
    - Hypotheses for the increased number of "unsure"
    - Please explain what motivated you to select your topic for the research project, etc.

16. Any other final questions or comments?

Interview questions modified in context and content for rural Aotearoa New Zealand setting from the following resources:

Riley, T. (2011). Qualitative differentiation for gifted and talented students. In R. Moltzen (Ed), *Gifted and talented New Zealand perspectives, 3rd Edition (pp. 276-303). Malaysia: Pearson.*

Roe, M., F. (2009). *Differentiation in middle level literacy classrooms: The Students Speak*. Washington State University, Tri-Cities. Available from http://files.eric.ed.gov/fulltext/ED507336.pdf.

Clipart taken from clipart panda. Accessed 27, April, 2015: http://www.clipartpanda.com/categories/science-clip-art-free.

Appendix Z.
Evaluating Whānau Focus Group Questions in Hui Setting

Whānau Focus Group *Evaluating* Hui **Date ________________**

Introduction:

Since we last met, the teachers reviewed your feedback from our December whānau focus group as well as the input from student surveys, focus groups, and classroom observations. They met over the summer to map out a 2016 curriculum committed to increasing relevance, choice, hands-on opportunities, and pre/post assessment. This second (and final!) focus group is created to evaluate the recent changes. It gives you a chance to share your version of what is happening in the 2016 years 9 and 10 science classrooms. The results of this focus group will be used to help the Science Department teachers as they continue to adjust and modify what and how they teach.

As before, in order for me to concentrate on what you are saying, I would like your permission to audio record our conversation. All recorded comments will be transcribed. To ensure confidentiality within the group, we ask that all participants sign a confidentiality statement. I, too, sign this statement. You have the right to ask me to turn off the recorder at any time, and to respond only to those questions of your choice.
Do you have any questions?

Focus Group Questions:

1. What do you know about your child's science experience so far in 2016 at XXXX College?
   (Topics studied, products produced, skills gained, level of growth, engagement, interest, etc.)

2. Please describe any changes (good and/or bad) to your child's science experience that you have noticed since we last met in December.

3. Years 9 and 10 science teachers met over the summer to map out a curriculum committed to increasing relevance, choice, hands-on opportunities, and pre/post assessment.

   A) How have the science teachers increased the ***relevance*** of:

      1) What they teach (Content)?

      2) How they teach (Process)?

      3) How they assess student learning (Product)?

   B) How have science teachers increased the level of student ***choice*** in:

      1) What students study (Content)?

      2) How students learn (Process)?

      3) How students demonstrate what they have learnt (Product)?

C) How are science teachers incorporating *hands-on* learning into their teaching this year?

D) How are science teachers incorporating students':

1) Prior knowledge into science lessons this year?

2) Interests into science lessons this year?

4. Do you feel your child is learning more/the same/less in 2016 when compared to previous science classes? Explain.

5. Another area of importance emphasised by whānau in our December focus groups was proactive communication between the school and home as well as within the department/school.

A) What changes have you noticed?

B) Are you satisfied with the current level of communication?

C) If not, what improvements would you still like to see take place?

5. How has the school's science department supported your child's learning in 2016? *(i.e. Addressing individual strengths and weaknesses and factoring this into teaching and learning?)*

6. "Not everyone learns the same things, in the same ways at the same time" (Riley, p. 276). Educators use the term differentiation to describe an awareness of and ability to meet individual student interests, strengths, and needs in the classroom.

A) What type of modifications made by 2016 science teachers are currently working for your child?

B) What do you wish your child's science teacher would do to help your child learn better?

7. Do you feel that your child is learning more/the same/less in 2016 science classes when compared to previous years? Explain.

8. Do you feel that your child is being challenged more/the same/less in 2016 science classes when compared to previous years? Explain.

9. According to April student online surveys, the number of students who believe that science is relevant to their lives, culture, and whānau has dropped substantially since December. Any ideas on why this might be?

10. How are whānau and/or the community currently involved in helping to make science engaging and relevant to real life for years 9/10 (Pre-NCEA Level Classes) at school?

11. How should whānau and/or the community currently be involved in helping to make science engaging and relevant to real life for years 9/10 (Pre-NCEA Level Classes) at school?

12. What else do you think would be important for the research project to know about you, your whānau, or community?

13. What could the science department and/or school do to help challenge your child to better learn that my previous questions did not cover?

14. Any other final questions or comments?

Interview questions modified in context and content for a rural Aotearoa New Zealand setting from the following resources:

Riley, T. (2011). Qualitative differentiation for gifted and talented students. In R. Moltzen (Ed), *Gifted and talented New Zealand perspectives, 3rd Edition (pp. 276-303). Malaysia: Pearson.*

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