

Science and Mathematics Education Centre

**Examining the Effectiveness of Including Aboriginal Perspectives to
Engage Aboriginal Students in High School Science**

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**This thesis is presented for the degree of
Doctor of Philosophy
of
Curtin University**

December 2016

Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgement has been made.

Signature:

Date: December 6, 2016

Abstract

It is widely acknowledged, both in Australia and internationally, that interest in science is declining, and scientific literacy is being viewed as a priority for twenty-first century education. With respect to Aboriginal students, a more significant disparity is noticeable as, Australia-wide, few Aboriginal students pursue science education or careers once they leave high school. Aboriginal students' results in international tests of scientific literacy suggest that initiatives to improve the education of Aboriginal students, have had little effect to date and Aboriginal students remain over-represented at the lower levels and under-represented at the upper levels of proficiency.

This study, therefore, investigates the effectiveness of embedding Aboriginal perspectives into the science curriculum to improve the level of engagement amongst Aboriginal students. The initial phase of the study involved establishing an Aboriginal Consultative Group as integral to the Aboriginal research process, so as not to perpetuate past practices which may have disregarded Aboriginal people. Aboriginal people are no longer allowing themselves to be scrutinised for the sake of research unless it is developed in partnership with them. The study, therefore, acknowledges that Australian Aboriginal people belong to the oldest living culture on earth and are the traditional owners of the land. Further, the unique relationship that Aboriginal people have with their traditional lands and waters, as well as with their history, culture, customs and beliefs, is recognised. The Aboriginal Consultative Group guided the purpose, aim, design resources and cultural protocols of the study, thereby generating mutual agreement, understanding and partnership in the research process.

My research approach and methodologies were also underpinned by current theory and practice recognised by the Aboriginal Research Academy and recommended for non-Aboriginal researchers. I implemented a methodology that placed Aboriginal knowledge and methods on an equal footing with Western knowledge and methods, and integrated both when appropriate. To this end, the Aboriginal research method of yarning was used together with the ethical guidelines recommended by the National

Health and Medical Research Council and the Australian Institute of Aboriginal and Torres Strait Islander Studies. This method was complemented by the Western research method of observation framed by a qualitative research paradigm that drew on critical theory, interpretivism and action research.

The study involved a group of 25 year nine Aboriginal students, both male and female, from a school in Perth. The results indicated that embedding Aboriginal perspectives and cultural knowledge into the science lessons increased the emotional and behavioural engagement of the Aboriginal students significantly and also led to a deeper understanding and valuing of Aboriginal culture for all students.

In providing possible reasons for these observable differences in student engagement, analysis of the yarns held with the research participants indicated that there were four main reasons for the change in their engagement: 1) increased sense of connectedness; 2) improved confidence in Aboriginal students; 3) appeal to Aboriginal students' learning strengths; and 4) changing perceptions about learning science held by the Aboriginal students.

The research reported in this thesis is significant because it is one of the first studies that have trialled the embedding of Aboriginal perspectives in middle school science in Western Australia. The results offer significant understandings of how embedding Aboriginal perspectives in science could promote Aboriginal students' engagement in science classes. The findings thus add to the literature that attests to the premise that Aboriginal students engage more productively with the curriculum if it reflects their culture.

The findings of this study are the basis for the development and presentation of a step-by-step guide to help teachers to embed Aboriginal perspectives in science. Further, it is anticipated that the positive results will encourage teachers and administrators to mobilise changes in practice that lead to more equitable outcomes for Aboriginal students in science.

Acknowledgement to Country



Photograph 1: *Kaya Wanju*– Hello and Welcome
Lance Pickett (with permission)

I wish to acknowledge that I live and work on Aboriginal traditional country and pay my respects to the Elders past, present and future. It is on their ancestral lands that my research was conducted on and involved Aboriginal people. My research acknowledges and uses Aboriginal knowledge that is embedded within the Aboriginal Custodianship of Country.

Dedication

This thesis is dedicated to:

My God who blesses me daily with strength and good health, and for my inspiration from Proverbs 4:6-7, “Do not forsake wisdom, and she will protect you; love her, and she will watch over you. Wisdom is supreme; therefore get wisdom.”

To my parents and siblings for their unwavering support and prayers from my birth until now. Especially to my mother, who received little education herself but who, gifted with an innate intelligence, knew early in life that education would be a powerful liberating force for her children. Battling Apartheid, oppression and hardship, her struggle turned to joy as she watched education reshape the lives of her children and also rewrite her destiny.

To my beloved husband Rodney, for always being the rock in my life and for ensuring that our family should want for nothing. Your support during my PhD journey has been remarkable considering how long it has taken me. Your patience and tolerance of my many hours and late nights at the computer is much appreciated. I promise to now commit more quality time to our relationship and, of course, cooking you more masterful meals.

To my precious daughters, Taryn Cherise, Jade Ann and Rebecca-Jo, I know having a mother who was always studying wasn't much fun but I know that you too will go boldly in the direction of your dreams and be the best at whatever you do; who knows, even a PhD. Now that this journey is over, I dedicate myself and my time to you and your children.

Acknowledgements

In 2003, I walked into a school in Perth, with a very rudimentary understanding and knowledge of Aboriginal people and students in Australia. Fourteen years later, I find that I have been on a journey of friendship and endless discoveries, that have included: *Yawuru* people (the Native title holders of the Western Australian town of Broome), whose land meets the sky and where the desert meets the sea; the *Anangu* people who helped me to follow in the footsteps of their ancestors and taught me about the land, caves and rocks that hold deep meaning and spiritual life; the *Palawa* people of Tasmania; the *Gadigal* community in Sydney; the *Kulin Nation* of Melbourne, the *Ngunnawal* and *Ngambri* groups of Canberra; and the traditional owners of the land, waters and islands of Darwin, the *Larrakia* people. All of these people welcomed me into their circles and I thank them for their generosity of spirit.

I could not have come this far without the support of many Aboriginal Elders, families and community members. In particular, I am exceedingly grateful to the late Aboriginal Elders Harry and Shirley Thorne, who taught me the cultural protocols required when working with Aboriginal people, which continue to guide my journey in this place I now call home, where the *Nyoongar* people have lived for over 60,000 years. Filled with an immense wisdom and knowledge, both Harry and Shirley shared their unique culture with me, convincing me to try witchetty grubs (which taste like raw almonds), kangaroo, goanna, turtle, and berries, all of which would keep me alive if ever I got lost in the bush. Warding me away from Warra Wirrin (bad spirits) and towards the Quop wirrin (good spirits) — I am forever grateful to them and will always keep their stories and culture alive.

My colleague and friend, Kayleen Hayward: Kayleen, too, has shared her traditional knowledge with me and also champions the cause of embedding Aboriginal perspectives in the curriculum. A teacher for over 30 years, she has overcome many obstacles of oppression and discrimination through education and her powerful connection to the land, her culture and her people, I am honoured that someone of

her worth has given her blessing to this study and continues to partner with me as we try to enhance the educational outcomes for Aboriginal students under our care.

Thanks to my supervisor, Professor Jill Aldridge, for encouraging me to enrol for a PhD and believing in my ability to succeed on this journey. You valued my work with Aboriginal students and recognised that others should know about it too. Your patience, encouragement, support, suggestions and recommendations have been invaluable to my project. I have been extremely fortunate to have had a supervisor of your worth guiding me along this arduous yet rewarding path. I have grown not only as a researcher but have gained personal strengths of resilience and perseverance. You are inspirational and I am forever indebted to you for helping me to achieve the accolade of PhD.

To my co-supervisor, Dr Marianne McLaughlin, thank you for joining me on this journey, shepherding me along the way and encouraging me always to 'never give up'. You, also, have enriched my study with your specialised knowledge on Aboriginal education, and this connection helped shape the final completion of this thesis. I am deeply indebted to you for giving your time to making this thesis a reality.

Thanks to Dr Christina Houen of Perfect Words Editing for editing this thesis according to the standards of the Institute of Professional Editors (IPEd).

To my case study teacher, thank you for welcoming me into your science classes and for allowing this study to be carried out. I am indeed indebted to you for restructuring your lessons, schedules and topics to accommodate the Aboriginal guest speakers and perspectives into your science lessons. Teachers like you make a world of difference in an Aboriginal child's life, and your commitment to this curriculum initiative is highly appreciated.

I am deeply grateful to the Aboriginal community members who became involved in my study. I am thankful to the Elders and members of the Aboriginal community for

supporting my project and helping me to maintain all of the cultural protocols. Having your support has made this research both authentic and valid.

Thank you to the guest presenters for providing the Aboriginal intelligence and exposing the students to scientific concepts through Aboriginal cultures.

Finally, thanks to the Aboriginal students who welcomed me into their unique culture.



Photograph 2: Strong Culture Strong Minds

Students from left to right: Xavier Dhurrkay, Arnold Punch, Emmanuel Loo, Brett Woods, Cedric Anderson and Dean Cooper (with permission).

Acknowledgement of the Artwork in this Thesis

The artwork used in this thesis, *Footprints of Change*, was provided by Reikeisha Miles. In her painting, Reikeisha has captured the old and the new ways. She depicts traditional Aboriginal culture and the Dreamtime and weaves them into a contemporary educational setting, demonstrating how both ways can co-exist.

Use of Terminology

I have made every effort to ensure the quality and authenticity of this research. Further, I have respected the Aboriginal people of Australia, especially in regard to how Aboriginal people choose to be known. Historically, the naming of Australia's first people has been shrouded by the scars of colonialism, with their names reflecting their colonisers' legacy, rather than the original inhabitants. In Linda Tuhiwai Smith's (1999, p. 80) words: "They came, they saw, they named, they claimed". Names were often used in a derogatory context, and the First Australians were often called savages and primitive natives.

As part of the historical revisioning of the First Nations People of Australia, this research seeks to reflect the wisdom of the Aboriginal Consultative Group and the many Aboriginal people with whom I work daily, who have guided me in the use of the correct terminology to describe the original people here in Western Australia. The most common terms used in Australia are Indigenous, Aboriginal, Aborigines, or Aboriginal and Torres Strait Islanders. It was clear that the term Indigenous is no longer viewed as acceptable, as historically it was used to categorise Aboriginal people together with the native flora and fauna of the country. The term Aboriginal has emerged as an acceptable term that is used throughout this thesis except in direct quotations.

Table of Contents

Declaration	i
Abstract	ii
Acknowledgement to Country	iv
Dedication	v
Acknowledgements	vi
Acknowledgement of the Artwork in this Thesis	ix
Use of Terminology	ix
Table of Contents	x
List of Figures	xv
List of Tables	xv
List of Photographs	xv
Chapter 1	1
Introduction and Rationale	1
My Unique Thread: From South Africa to Australia	2
Research Questions	7
Significance of this Study	8
Research Paradigms	9
Research Methodology	11
Ethical Considerations	14
Overview of Chapters	17
Chapter 2	19
Theoretical Framework	19
Positioning Myself as a Non-Aboriginal Researcher	19
The Development of a Research Framework	21
Narrative: Yarns with Aunty Kay	22

Aboriginal Paradigm: A Decolonising Framework	24
Recognition of Aboriginal Worldviews, Knowledges and Realities	26
Inclusion of Western Paradigms	34
Conclusion	37
Chapter 3	38
Literature Review	38
Part One: A Brief History of the Education	38
of Aboriginal Children in Australia	38
Civilising Aboriginal Children	39
Mission Education	40
The Protection Period	42
Assimilation Period	44
Tides of Change	45
Part Two: Australian Aboriginal Educational Achievement in Science	48
Aboriginal Students' Science Performance	48
Barriers to Science Achievement	53
Part Three: Embedding Aboriginal Perspectives: Culturally Responsive Curricula	58
The Culturally Responsive Curriculum Movement in Australia	59
Challenges of Embedding Aboriginal Perspectives	65
Embedding Aboriginal Perspectives: Improving Student Outcomes	70
Embedding Aboriginal Perspectives: Student Engagement	72
Conclusion	79
Chapter 4	81
Methodology and Methods	81
Research Design	82
Phase 1: Consultation with an Aboriginal Consultative Group	83

Phase 2: Selection of the Research Site and Participants.....	90
Phase 3: Implementation of the curriculum innovation.....	92
Research Methods.....	94
Classroom Observations.....	94
Yarning as a Research Method.....	100
Analysing the data.....	103
The Standards Used.....	109
Ethical Considerations.....	113
Informed Consent.....	113
Permission.....	114
Privacy and Confidentiality.....	114
Consideration.....	115
Conclusion.....	115
Chapter 5.....	116
Results:.....	116
Observations of Student Engagement.....	116
Frequency Counts.....	116
Impressionistic Tales.....	118
Impressionistic Tale One: An hour in a Regular Science Class.....	118
Impressionistic Tale 2: Learning science using Aboriginal perspectives.....	126
Interpretative Commentary: Aboriginal Student Engagement Pre- and Post- Innovation.....	137
Chapter 6.....	146
Results:.....	146
Yarning about Science Engagement.....	146
Theme 1: Fostering Connectedness.....	146
Connectedness to the Curriculum.....	147

Connectedness to the Teacher.....	154
Connectedness between Aboriginal and non-Aboriginal Students.....	157
Connectedness with Aboriginal Parents and the Community.....	160
Theme 2: Enhanced Confidence	163
Abilities and Aptitudes.....	163
Leadership.....	165
Theme 3: Promotion of Aboriginal Students' Learning strengths.....	169
Learning Strengths	169
Theme 4: Changing Perceptions of Science.....	175
Aboriginal Students' Perspectives	177
Chapter 7.....	180
Discussion and Conclusion	180
Reconsidering the Research Questions: My Reflections	180
Student Engagement: Embedding Aboriginal Perspectives in Science Lessons	182
Reasons for Improved Engagement.....	183
Embedding Aboriginal Perspectives in Science: A Guide for Teachers.....	192
Limitations	192
Summary of Recommendations	194
Significance.....	196
Concluding Remarks.....	199
References.....	201
APPENDIX A	255
Information Sheet and Consent Form: Students	255
APPENDIX B	259
Information Sheet and Consent Form: Parents	259
APPENDIX C	263

Information Sheet and Consent Form: Teacher	263
APPENDIX D	267
Information Sheet and Consent Form: Principal.....	267
APPENDIX E	271
Ethics Approval: Department of Education	271
APPENDIX F.....	273
Ethics Approval: Curtin University	273
APPENDIX G	275
A guide for consultation with Aboriginal people.....	275
APPENDIX H.....	277
Year 9 Term 3 Science Program 2010: Embedding Aboriginal Perspectives	277
APPENDIX I.....	280
The key steps involved when considering how to embed Aboriginal Perspectives in Science Lessons.	280
Starting Point: Embrace Aboriginal Histories.....	281
Step 2: Welcome Aboriginal Culture into the Science Classroom	282
Step 3: Understand Aboriginal Social Realities.....	282
Step 4: Position your Personal Standpoint.....	283
Step 5: Becoming Culturally Responsive	284
Step 6: Consult and Connect with your Local Aboriginal Community	286
Step 7: Develop Aboriginal Teaching Pedagogies.....	287
Step 8: Innovate the Science Curriculum.....	288
Step 9: Assess and Evaluate Equitably	290
Step 10: Celebrate Success	292

List of Figures

Figure 2.1:	Guiding principles for an Aboriginal research framework.....	25
Figure 3.1:	Comparison of TIMMS results for Aboriginal and non-Aboriginal students.....	52
Figure 4.1:	Three-phased research design.....	83
Figure 4.2:	Stages of the implementation	92

List of Tables

Table 3.1:	Mean science scores for each PISA testing cycle: 2000, 2003, 2006, 2009 and 2012.....	50
Table 3.2:	Comparison of National Year 6 Science Test scores for Aboriginal and non-Aboriginal students (2003, 2006, 2009 and 2012) in Australia.....	53
Table 4.1:	Indicators of Engaged and Disaffected Behaviours	98
Table 5.1	Frequency Tally for Behaviours Indicative of Engagement and Disaffection for Regular and Curriculum Innovation Science Lessons.....	118
Table 5.2:	Summary of the observable trends in Aboriginal students' behaviour in regular and innovation lessons.....	140

List of Photographs

All photographs used in this thesis were done so with the permission of the persons depicted and, in the case of students, the permission of a parent or caregiver.

Photograph 1:	Kaya Wanju– Hello and Welcome	iv
Photograph 2:	Strong Culture Strong Minds.....	viii

Chapter 1

Introduction and Rationale

This thesis reports the evaluation of an innovative programme that embeds Aboriginal perspectives into the science curriculum. This study examines what happens when Aboriginal perspectives are included in the teaching and learning of science in terms of Aboriginal students' attitudes, behaviour, motivation and self-confidence. The study stems from numerous statistics which indicate that Aboriginal students are underrepresented in science courses and lack confidence in their ability to study science-oriented courses. Given that Aboriginal people are one of the most educationally disadvantaged groups within Australia (Steering Committee for the Review of Government Service Provision, 2014), and do not participate equally with their non-Aboriginal counterparts, at any levels of education (Australian Bureau of Statistics, 2015), there is an urgent need to research and develop appropriate strategies to break this impasse. There is much literature to suggest that this impasse is traversable when Aboriginal students' learning of science is connected to Aboriginal cultures, therefore this study is timely (Aldous, Barnes & Clark 2008; Bull, 2008; Kulig, Duke, Solowoniuk, Weaselfat, Shade, Lamb & Wojtowicz, 2010; McKinley, Jones Brayboy & Castagno, 2008).

Aboriginal students are at the interface of a Western and an Aboriginal culture (Nakata, 2001). Given that the Australian science curriculum reflects the principles and beliefs of the dominant Western culture, a considerable shift is required if Aboriginal students are to experience science in a way that is meaningful and relevant. Therefore, contextualisation of Aboriginal cultural worldviews in the science classroom is likely to benefit not only the Aboriginal students but also their non-Aboriginal counterparts who may hold a generalised or stereotypical view of Aboriginal people and Aboriginal cultures.

As a migrant to Australia, I also have held perceptions about Aboriginal people that were shaped by the media, long before I actually met an Aboriginal person. In the next section, I share my story, in a bid to reveal my own unique thread and the

connection that I feel to Australian Aboriginal peoples and, in the process, demonstrate how this research examined the effectiveness of embedding experiential knowledge applied by Aboriginal people through their own science for the past 60,000 years or so. I also introduce my research questions, which are the fundamental core of my study, and then proceed to demonstrate how the research questions helped me to determine the significance of my study, the research paradigms and methods, the limitations and ethical considerations. I conclude the chapter by presenting an overview of the subsequent chapters as an indication of how my thesis is constructed.

My Unique Thread: From South Africa to Australia

This thesis was written through the eyes of an Australian immigrant. It was the winter of 1998 when I moved to Western Australia. “Packing for Perth” had been a buzz phrase for many years during the Apartheid era and even though I loved my homeland, South Africa, and still do, it was time to make a change. I wanted to escape the injustices of Apartheid and to explore a new life in Perth, Western Australia. Life in our new country promised to be peaceful and safe. Like Martin Luther King, I too had a dream of the day when my children would be judged, not by the colour of their skin but by the content of their character (King, 1992). Moving to Australia was lauded as the answer to these twin conundrums. My research on Australia promised endless blue skies, spectacular natural landscapes, unique wildlife, abundant sun, white sandy beaches and good food; this promise coupled with the spiel from the migrant agents left me feeling relatively confident about what to expect.

Before I came to Australia I had read about the Aboriginal people and how they shared a history that was similar to my own, as a person of colour. The same system that was employed in Australia, the Queensland Aboriginal Act (Korff, 2016), to disenfranchise the Aboriginal people, had been exported to South Africa and used as the foundation for laws related to Apartheid.

I had never met an Aboriginal person and, when I landed at the airport, I was rather surprised that there were no visible brown or black-skinned people but, rather, a

predominately white sea of faces. My use of the term “white” is not intended to be disparaging but, rather, stems from my historical roots of being defined by my colour. I was born during an ignominious period of South African history. As a person of colour, I automatically and legally inherited a life of discrimination through South Africa’s official policy of racial segregation that involved political, legal, and economic discrimination against non-Whites.

This system, known as Apartheid, ensured that the original inhabitants of the land and people of different ethnic groups were separated and legally administered by means of separate housing, education, marriages, and public facilities under the Apartheid laws; almost everything was designated according to colour. Being geographically and socially separated from White people left me with minimal contact with them. Naturally, I mixed more with the so-called non-White groups and this, for me, was comfortable. I married into my own racial group, had children and forged my teaching career in the so-called Black system of Education. However, the dismal shame of Apartheid in South Africa has cast a shadow over my existence. I still cannot speak the language of my forefathers, yet I am proficient in the language of the Apartheid government. For me, liberation is achieved through education. I view education as the key that unlocks the door to many opportunities and a more enriched life. It is this belief that led me to explore options to seek a new way of life.

I had imagined that this new life in Australia would include Aboriginal people. I had become a passionate teacher over the past 12 years, seeking to empower Black South African students to realise their dreams. Finding a job in the education sector was not difficult but it was, indeed, a culture shock. I had not expected to walk into classrooms predominantly occupied by White students. I had never taught White students before, as this was not allowed under the apartheid system. I remember scanning the classroom, looking for some brown faces, searching for something familiar. Living exclusively in a Black world in South Africa had certainly not prepared me for this. Under the apartheid system, I had felt inferior to Whites and had assumed that I would have to work extra hard to teach White students. I soon learnt that, yes, there were some smart White students and there were those who were average and some who were below average, BUT in the end, they were all just

kids. I actually found myself re-learning and re-configuring my perceptions and patterns of thinking that had been enculturated during my apartheid upbringing.

I quickly started to enjoy my experiences in the Australian classrooms. My teaching took me all across the Perth metropolitan area. In my classrooms, I found the Aboriginal students that I had been looking for, but not as described in many books. Some were dark-skinned, some brown and some, to my new found understanding, could even look white.

As I found out more about the Aboriginal students in my classrooms, I became aware that I had been naïve about the macro and micro politics surrounding Aboriginal education. My personal experiences in Australia had not been marked by racism or any other prejudice. It concerned me, however, that I had left a country that discriminated against the traditional people of the land and that I was now confronted by the bleak state of affairs in the Aboriginal community. Disturbing figures such as the number of deaths per 100,000 people in the 15-24 age group, which was almost three times as high for Aboriginal and Torres Strait Islander people as for non-Aboriginal people (between 2005 and 2009), alarmed me (Australian Bureau of Statistics, 2009). Important to this research was the discovery that only 38 per cent of Aboriginal students were completing year 12 compared to 76 per cent of their non-Aboriginal peers (Australian Bureau of Statistics, 2008). These figures were confronting, given that I had witnessed thousands of non-White students in South Africa striving to complete Year 12 as a means of ending poverty and improving their lot in life.

It seemed that, as a skilled migrant, I could enjoy a good standard of living, but that this was not the case for the Aboriginal students, who were not at the same level as their non-Aboriginal counterparts (Ministerial Council on Education, Employment, Training and Youth Affairs, 2000). My background had led me to be concerned about issues of inequity and I was drawn to the disparity facing Aboriginal students. I envisaged that I could use my worldview as an anchor to help Aboriginal children to bridge the educational gap that they were experiencing.

A job opportunity within Aboriginal education in Western Australia has served to place me at the centre of many Aboriginal students' learning journeys. This dream job, as a coordinator of an aspiration strategy for Aboriginal students, has provided me with the challenging and rewarding role of supporting Aboriginal students as they strive to achieve secondary school graduation. It was during the course of my work that I came across the concerning anomaly: Aboriginal students were not selecting science subjects as often as their non-Aboriginal peers. This problem was probably exacerbated by Aboriginal students' poor performance in science, which indicated that the average scores for Aboriginal students placed them on a par with students in low-performing countries such as Chile and two and a half years behind the average for their non-Aboriginal contemporaries (Thomson, De Bortoli & Buckley, 2013).

In attempting to find reasons for Aboriginal students' lack of engagement in science, I consulted with a group of Aboriginal Elders, teachers and academics. Thus, my journey to find answers to this problem became something of a pilgrimage, as I traversed through the unique Aboriginal cultural landscape. The Dreamtime became the backdrop for this research as I learnt that the only way forward, as recommended by the Elders, was to realise that at the heart of Aboriginal learning is their culture. For Australia's Aboriginal people, science is rooted in the Dreamtime, which, as explained by Dean (1996), refers to the ancestral spirits that transformed a pre-existing world of things and conditions into the structures that they are today. This primordial period is the very foundation of life itself, in which the ways of life, the law and moral codes were set down to be followed eternally. The Dreamtime encompasses the Aboriginal worldview and is discussed in detail in Chapter 2. This point is also made by Snively and Corsiglia, who note that "Western modern science has been taught at the expense of Aboriginal knowledge" (2000, p. 6). Ogawa (1995) also adds an important element when he suggests that "every culture has its own science, often referred to as Indigenous science" (Ogawa, 1995, p. 585).

Within this ephemeral space, valuable scientific knowledge can be found and incorporated into science lessons. Incorporating such material has the potential to allow Aboriginal students to cross cultural boundaries between Aboriginal culture and Western modern science. Bodkin, a Dharawal Elder and senior knowledge

holder for the Dharawal community in New South Wales, has coined the term “Black science” to define the system of observation and experience that explains Aboriginal notions of the weather, climate and conservation (Bodkin, 2010). Bodkin (podcast, 2010) explains:

Aboriginal knowledge is a science, because two of the most important elements of any of our sciences is observation, and it is actual experience. And those observations and experiences have been put into story. Now, some of those observations — some of our science — goes back 80,000 years. You guys have only been here 200-and-something years. Our knowledge is still out there, but everybody only has a little bit of it. And the knowledge-holders know how to put those little bits together.

Lester Rigney (2001, p. 2), acknowledges that:

More recently, Aboriginal peoples have embraced higher education and scientific research as tools for social and economic mobility, although with some reservation. Higher education is fundamental for preparing Aboriginal peoples with the necessary skills not only to reclaim, protect and nurture Aboriginal cultures but also to prepare the next generation for an ever-changing modern society.

Aboriginal engagement in the sciences at the tertiary level is comparatively low. It was not until 1983 that Australia’s first Aboriginal doctor graduated (Australian Indigenous Doctors Association, AIDA, 2012). Further data from the Australian Indigenous Doctors Association indicates that, in 2009, Aboriginal and Torres Strait Islander doctors comprised approximately 0.2 per cent of the total number of medical practitioners in Australia (Australian Indigenous Doctors Association, 2012). AIDA (Australian Indigenous Doctors Association, 2012) stresses the importance of Aboriginal health workers healing their own people because they identify with the social and cultural contexts and are able to interpret Western medicine into Aboriginal ways of knowing. According to AIDA, Aboriginal doctors have the ability to empathise with Aboriginal patients, having the knowledge to ask the right questions about patients and extended family and, as such, are in a better position to build trust.

Research Questions

Thus, my research journey has involved trialling the embedding of traditional Aboriginal knowledge at a middle school in Perth with a group of Year 9 Aboriginal students. It is important that, at the dawn of the twenty-first century, we consider how we can address the deficit around Aboriginal education and, in particular, science education. For this study, an Aboriginal teacher, Elders and guest presenters developed relevant cross-cultural science teaching materials and strategies which included Aboriginal children's personal, family and cultural histories. In initiating this research, I sought to align with the key priority of the National Aboriginal and Torres Strait Islander Education Action Plan 2010–2014 (Ministerial Council for Education, Early Childhood Development and Youth Affairs, 2010), which calls on teachers to ensure high levels of cultural and linguistic understanding and competencies that can be drawn on to inform the best practice for teaching Aboriginal and Torres Strait Islander students. The weaving of Aboriginal culture into the fabric of the science syllabus, for the purpose of this study, involved incorporating local Nyoongar knowledge into science lessons to investigate whether this improved the engagement of Aboriginal students.

The overarching aim of this study was to examine the effectiveness of embedding Aboriginal perspectives on Aboriginal students' engagement in science. There were two specific research questions which guided this study:

Research question 1:

What are the observable differences in the engagement of Aboriginal students when they are involved in Western science lessons and lessons that are embedded with Aboriginal perspectives?

Research Question 2:

What are the possible reasons for the increased engagement of Aboriginal students in science lessons that include Aboriginal perspectives?

Significance of this Study

This study contributes to the developing and significant base of research and literature that has examined the embedding of Aboriginal perspectives into the science curriculum, both nationally and internationally (Aikenhead, 1996, 1997, 2001; Michie 2002; Michie & Linkson, 1999; Michie, Anlezark & Uibo, 1998; Linkson, 1999; Nannes, 2000; Semali & Kincheloe, 1999; Van Eijck & Roth, 2008). The study adds value to the premise that authentic science experiences and the inclusion of Aboriginal knowledge in the science curriculum can improve scientific literacy and help to mediate students' orientations towards science and scientific careers (Aikenhead, 2000b; Ogawa, 1986; Ogunniyi, 1988).

There is a substantial body of evidence that identifies Aboriginal cultural knowledge as a major factor that can be used to enhance the outcomes for Aboriginal students (Aikenhead, 1996, 1997, 1998; Cajete, 1986, 1999; Christie, 1991, 1997; Snively, 1990, 1995). The findings of this study contribute to this body of evidence. Further, the study endorses past research that has found that the absence of Aboriginal knowledge renders science education inaccessible and irrelevant to Aboriginal people (Snively & Williams 2006). Significant to this research are other studies carried out in other countries which echo similar principles, including: Canada (Aikenhead, 2000a; 2000b; Bartlett et al, 2007; Cajete 2000; Snively & Williams, 2006); New Zealand (Mckinley 1996; Smith 1999); and Africa (O'Donoghue, Masuku, Janse van Rensburg & Ward 1999; Masuku-van Damme, 1997; Shiza, 2010).

In Australia, this research is significant as it has provided a space in which Aboriginal students have experienced Western science concepts within an Aboriginal setting. The research reported in this thesis has extended the findings of past studies that examined whether a renaissance of Aboriginal knowledge in the science curriculum might be a valuable tool in the classroom.

In summary, this research is significant because it builds on and extends past research that identifies possible barriers that prevent Aboriginal students from engaging in science. Furthermore, by exploring the possibility of embedding

culturally relevant knowledge into a science course with the goal of engaging Aboriginal students more effectively, the study examines how the Aboriginal worldview can be acknowledged, respected and, to some extent, preserved.

A significant contribution of this research is the development of Aboriginal resources which can be used by other science teachers. Further, the findings have led to the development of a step-by-step guide for teachers wishing to embed Aboriginal perspectives into the curriculum. As such, this study charts a course towards indigenising the science curriculum.

In terms of the methods, this study involves blending Western research methods with Aboriginal methodology. This method of researching Aboriginal people by a non-Aboriginal researcher provides a positive exemplar that will contribute to the mounting scholarly work that bridges the Aboriginal worldview and Western ideology. Further, the methods used could help other researchers wishing to adopt a similar approach to uphold and cement the emergence of Aboriginal research frameworks and methodologies.

Research Paradigms

A paradigm is “a set of beliefs about the world and about gaining knowledge that goes together to guide people’s actions as to how they do their research” (Wilson 2001, p. 175). Matching appropriate paradigms for this research involved looking at philosophical and theoretical frameworks that would inform and guide my methodology, including my research design, data collection and analysis. As a person of colour, I recognised that I viewed things differently from Caucasian people and, through my work with Aboriginal people, I have come to learn that they too have their own belief system. As such, I wanted my research to reflect the worldview of my research participants. Therefore, embedding an Aboriginal research paradigm was central to this study.

Kuokkanen (2000, p. 417) cites three characteristics of what he refers to as an Indigenous paradigm:

- It has a clear social and political agenda which aims at the overall decolonisation of Aboriginal societies.
- It maintains a critical stand towards Western metaphysical dualism which still informs much of current patterns of thinking and research practices.
- It is based on a holistic approach which strives towards a balance between different areas of life and which does not separate intellectual, social, political, economic, psychological and spiritual forms of human life from each other.

As this study places an emphasis on the voices and lived experiences of the research participants, this paradigm fits well with my research.

My research was also informed by two Western paradigms which complement the Aboriginal paradigm: interpretivism and critical theory (introduced here and discussed further in detail in Chapter 2). Interpretivism (see for example, Guba & Lincoln, 2005; Schwandt, 1994), allowed me to explore and reveal the perspectives of the research participants using naturalistic methods. As noted by Bevir and Kedar (2008), interpretive methodologies encompass an experience-near orientation that views human action as meaningful and historically contingent. It was recognised in this research that the Aboriginal research participants would bring their own unique interpretations and construction of the world and, therefore, I needed to be open to the attitudes and values of the participants and to suspend prior cultural assumptions (as recommended by Mackenzie & Knipe, 2006).

Similarly, critical theory, which espouses reflective assessment, is a complementary paradigm that I drew on when working in this Aboriginal context. Critical theory aims to transform society and to address inequality, particularly in relation to ethnicity, gender, sexual orientation, disability, and characteristics of other marginalised groups in society (Mackenzie & Knipe, 2006). Critical theory was a highly valued paradigm in this study, as the main premise of my research recognised that research is not value free and does not reflect only one interpretation. To bring about change in the Aboriginal research arena, critical theory was drawn on to

challenge the mono-cultural view and to reflect the epistemologies and ontologies of the Aboriginal research participants (Martin, 2000).

Research Methodology

The methodology that one adopts for research refers to the general research strategy that outlines the way in which the research was undertaken and also identifies the methods that were used (Creswell, 2009). Traditionally, Western research literature is used to inform a study. However, my study was informed by both Western and Aboriginal research methodologies, as I was keen to adopt a research methodology which would be respectful of Aboriginal people and their protocols. Aboriginal people in Australia are establishing procedures by which no research related to an Aboriginal issue is welcome without consultation and/or collaboration with the Aboriginal community under study. Further, such studies require clarification of the role of the studied community in the research and the impact that the research will have on the community (Bainbridge, Tsey, McCalman, Kinchin, Suanders, Lui et al., 2015; Bishop, Vicary, Browne & Guard, 2009; Bull, 2010; Glass & Kaufert, 2007; Rink, Bird ... et al., 2016).

It was important to bear in mind that research in Aboriginal domains must be compatible with the historical and contemporary experiences, philosophies and cosmologies of the people (Smith, 1999). Current trends in the research arena involving Aboriginal people indicate that “Indigenous people now want research and its designs to contribute to the self-determination and liberation struggles as defined and controlled by their communities” (Rigney, 1997a, p. 632). This notion is pivotal to the decolonisation of research methodologies (Mutua & Swadener, 2004; Zavala, 2013).

According to Smith (2013), it is important for non-Aboriginal researchers who are working with Aboriginal people to position themselves in relation to the people for whom the research counts. To this end, I included Aboriginal methodologies as alternative ways of thinking about the research processes, as recommended by numerous authors (Australian Institute of Aboriginal and Torres Strait Islander Studies [AIATSIS], 2012; Henderson, Simmons, Bourke & Muir, 2002; Kovach,

2009; Kahakalau, 2004; Nakata, 2007; Thomas, Bainbridge & Tsey, 2014; Whitman, 2007) as well as the Western qualitative research methodology, which aimed to capture the lived experiences of the social world and the meanings that people gave to these experiences (Corti & Thompson, 2004).

I adopted the position of writing in my own voice while simultaneously providing a platform for Aboriginal voices to be heard. I found myself feeling comfortable and confident as I approached this cultural interface, described by Nakata (2007, p. 199) as:

[A] space of many shifting and complex intersections between different people with different histories, experiences, language, agenda, aspirations and responses. As much as it is currently overlaid by various theories, narrative and arguments that work to produce cohesive, consensual and co-operative social practices, it is also a space that abounds with contradictions, ambiguities, conflict and contestation of meanings that emerge from these various shifting intersections.

Aboriginal methodologies have four common and unwavering principles that were used to guide this research: relational accountability; respectful representation; reciprocal appropriation; and rights and regulation. These principles are discussed in detail in the methodology section. Aboriginal methodologies in Australia also include Aboriginal standpoint theories that involve embedding Aboriginal knowledge, values, and beliefs. These also were embedded into this study, to avoid depending solely on Western theories.

The common principles of Aboriginal methodology theories were upheld in my study to ensure that my research was carried out in a respectful way that includes Aboriginal worldviews and knowledge. In addition, reference to the social, historical and political contexts which have impacted on Aboriginal people was included for contextualisation. Aboriginal research methodology is based on relational knowledge rather than individual knowledge (Wilson, 2001), hence an epistemological perspective, rooted in the local Aboriginal knowledge of the community and privileging Aboriginal voices, was used (Rigney, 2001). Therefore, my research

involved key Aboriginal community members as participants in the research process (by establishing an Aboriginal Consultative Group and using the knowledge of the local community) as a fundamental element of the methodology.

My research involved the use of principles related to participatory action research, which refers to the process through which researchers and stakeholders (those who potentially benefit from research results) work together in designing and conducting all phases of the research process, including the formulation of the questions, design, data collection, analysis, dissemination, and utilisation (McTaggart, 2001). Participatory research methodologies aligned well to Aboriginal research methodologies, as they provided shared ownership of the research project, community-based analysis of social problems and an orientation towards community action, as described by researchers such as Kemmis, McTaggart and Nixon (2013), Riecken, Conibear, Michel, Lyall, Scott, Tanaka et al. (2006) and Wilson (2008). Community participatory research principles included: the recognition of the community as a unit of identity; building strengths and resources within the community; facilitating collaborative partnerships in all phases of the research; integrating knowledge and action for mutual benefit of all partners; promoting a co-learning and empowering process that attends to social inequalities; involving a cyclical and iterative process; and disseminating findings and knowledge gained to all partners.

Participant observation (Anderson, Herr, & Nihlen, 2007; DeWalt & DeWalt, 2002), was also woven into the study. This method is viewed as a culturally relevant and preferred method by Aboriginal people to collect data about their people, processes, and cultures (Kawulich, 2005). Participant observation was also advantageous in that it afforded access to the “backstage culture” (De Munck & Sobo, 1998, p. 43), that is, it allowed a richly detailed description and provided opportunities for viewing or participating in unscheduled events.

The process of conducting this type of research involved gaining entry into the Aboriginal community, selecting Elders and key community members and participating in community consultation. The method called on me, the researcher, to

clarify my findings through member checks, formal interviews and informal conversations, and keeping organised, structured field notes to facilitate the development of a narrative that explained various cultural aspects to the reader (Kawuilch, 2005). At all stages, the method of data collection was respectful of and included Aboriginal protocols, values and beliefs that were important to the community that I was working with. The collection of data was seen as a means of expressing ways of knowing, being and doing (Martin, 2008). Data collection was, therefore, subjective, naturalistic and generally non-statistical (Denzin, 2005).

Ethical Considerations

Involving Aboriginal people as participants in a research project that concerns them enables a shared understanding of the aims and methods of the research, and the sharing of the results of the work. Involving Aboriginal people affords respect for their inherent right to self-determination, control and maintenance of their culture and heritage (Australian Institute of Aboriginal and Torres Strait Islander Studies [AIATSIS], 2012). At the onset, I acknowledged that, although I am a person of colour, I am not of Aboriginal descent and, as such, needed to be sensitive about the historical implications of research surrounding Aboriginal people. I established an Aboriginal Consultative Group to strengthen my role, as this group provided the Aboriginal knowledge that was needed for the curriculum initiative, cultural protocols and ethical issues. Sharing a similar history of being a victim of race discrimination and oppression facilitated a bond of trust and kinship with this group and the other participants. I also adhered to the guidelines for ethical Aboriginal research developed by the National Health and Medical Research Council (2003), that identify the following values that underlie ethical research with Aboriginal peoples: spirit and integrity; reciprocity; respect; equality; survival and protection; and responsibility.

In making a commitment to uphold research ethics with Aboriginal people as the main research participants, these values inspired me to make and sustain connections between my research participants and to implement best practice in this aspect of research protocols and ethics. Below I outline how I did this in respect to each value.

Valuing spirit and integrity involved me honouring the traditions and history of my research participants. My research was sensitive to the inherent spirituality and ceremonial customs in Aboriginal culture by acknowledging the links that bind the generations together. I was cautious of maintaining a Western assumption that an individual is the basic social unit (as recommended by Kovach, 2015). Rather, within the Aboriginal context, my emphasis was not only on the Aboriginal students as the research participants, but also their families, extended families, Elders and community members, all of whom contribute to Aboriginal children being who they are. In my study, this meant inviting these co-participants to be co-owners of intellectual property, consultants, designers of the Aboriginal curriculum, teachers and presenters. Furthermore, they clarified cultural protocols and Aboriginal ways of knowing and doing things. In some instances, I had input into the study through four generations, which further entrenched my recognition of maintaining spirit and integrity in my study. Having students say that this is my Pop or Uncle or Nan was not unusual in the study.

The value of reciprocity which underpins the shared responsibilities and obligations to family and land grounded on kinship linkages (National Health and Medical Research Council, 2003), encouraged me to consider the shared benefits of my research and a mutual obligation which recognised the contribution of my research participants and partners. My research was not self-motivated but, rather, aimed to have benefits that would be of value to Aboriginal students and the Aboriginal community at large. In doing so, it aimed to examine how engagement in science could be enhanced for Aboriginal students. These values were identified by the Aboriginal Consultative Group (developed as part of this study) as a key priority for the community members. Reciprocity, therefore, involved the exchange of ideas as to how best these could be achieved.

The value of respect focused on the regard that I had for the Aboriginal people involved in this study. Restoring pride, dignity and esteem to the research participants was a key consideration as, historically, these principles have been denied to them (Smith, 1999). Aboriginal people live on the basis of respect for land and culture, and mutual respect is both ethical and ensures integrity (National Health

and Medical Research Council, 2003). Valuing respect in my study meant building trust with my research participants, which was established through relationships that I had developed with Aboriginal people over the years and through professional development involving the Cultural Respect Framework for Aboriginal and Torres Strait Islander people (Australian Institute of Aboriginal and Torres Strait Islander Studies, 2012). Upholding cultural respect through sustained relationships with Aboriginal people helped me to source relevant people to join the research, to design and present curriculum materials and to authenticate the findings.

Having been marginalised for most of my life because of my skin colour, the value of equality was a major consideration for my study. Recognising that all people are equal and that fairness and justice should be a fundamental right was grounded in my study and all of my interactions with the Aboriginal research participants. I placed a strong emphasis on ensuring that the three components of equality (valuing knowledge and wisdom, equality of partners, and the distribution of benefit) were embedded at all stages of the research (National Health and Medical Research Council, 2003). Aboriginal scientific knowledge was used alongside the Western scientific knowledge on an equal basis. Even though the presenters of the Aboriginal scientific knowledge did not hold Western science degrees, I ensured that the knowledge that they brought to the study was valued. The wisdom, experience and skills set that the Aboriginal presenters brought to the study were presented to Aboriginal and non-Aboriginal students as knowledge that was both sacred and beneficial to scientific development and sustainability in the world.

The value of survival and protection was an integral precursor to how I constructed my study, the research methods and methodology and the dissemination of the findings. The value of survival and protection, particularly of Aboriginal cultures and identity, was a unique thread which ran throughout this study in a bid to protect Aboriginal cultures and identity (National Health and Medical Research Council, 2003).

The value of recognising Aboriginal peoples' connection to country, kinship, and spirituality was a priority for me, to ensure that I worked in an ethical way and

minimised harm in my research by involving Aboriginal people in all stages of the research (including an Aboriginal Consultative Group, using Aboriginal guest presenters, and teachers). Involving Aboriginal people ensured that my research was implemented in a culturally safe environment. In doing this, I also adhered to the Guidelines of the National Health and Medical Research Council (2003).

Overview of Chapters

In Chapter 1, I have introduced the reader to the topic and outlined the research reported in my thesis. I have provided a brief personal journey to contextualise this study's significance and meaning for me. The chapter describes how this research was defined by Aboriginal people and has followed the correct protocols when researching Aboriginal people. A background to the study is provided, and the research questions and conceptual framework are introduced. The reader is also provided with an overview of the significance of the research.

In Chapter 2, the key variables that can be included in the development of a theoretical framework are described. I present the rationale for selecting the key variables in my theoretical framework and how these reflect my own ontology. I then go on to discuss the use of Aboriginal and Western paradigms as significant models in my research.

In Chapter 3 I provide a review of literature pertinent to my study. This review is presented in three parts. In the first part, I address the early education of Aboriginal children. In the second part, I examine the literature related to the concept of engagement and Aboriginal students' engagement in science. I also address some of the barriers experienced by Aboriginal students' that hinder their engagement in science. In the third part, I discuss the culturally responsive curriculum movement and provide an understanding of what embedding Aboriginal perspectives means. The challenges that face practitioners who seek to embed Aboriginal perspectives are explained. Finally, in this part, I look at research related to embedded Aboriginal perspectives and improved educational outcomes as well as evidence-based practice of embedding Aboriginal perspectives in science.

Chapter 4 provides details of the key elements that may be used in the development of a methodology to assess Australian Aboriginal students' engagement in a prescribed school science subject. This chapter outlines the methodology of the research and details the techniques, sample, data collection, approaches, and theoretical frameworks that were used in the study. A description of the procedures, as well as a background to the methodology, is also provided.

In Chapter 5 I report the results of the second research question which examined the observable differences in the engagement of Aboriginal students when they are involved in Western science lessons and lessons that are embedded with Aboriginal perspectives. I use the data gathered through observations and present the differences in an Aboriginal and non-Aboriginal format to uphold my dual methodology which was explained in Chapter 2. I present two narratives which allowed me to contextualise my research and develop my argument while staying true to the Aboriginal tradition of storytelling and using Western methods. Finally, I delineate the observable differences in a linear, tabulated format to help to explain the variances I observed.

In Chapter 6 I present the results of data analysis of the yarns with the research participants and the themes that emerged. I utilise my dual methodology, explained in Chapter 2, to creatively examine the possible factors which influenced the engagement of the Aboriginal students in science in this research.

In Chapter 7 I summarise the findings and consider how my findings corroborate with or differ to past research. I examine how my findings develop further understanding from a localised perspective and, more importantly, from an Aboriginal perspective. In the process, I seek to highlight convergent and divergent views, strengths and weakness and examine the implications of the findings in relation to current theory and professional practice in Aboriginal education pertaining to science.

Chapter 2

Theoretical Framework

This chapter addresses the key variables that influenced the development of a theoretical perspective for a study that involved Aboriginal students. These variables guided my research as I sought to understand what processes were needed when carrying out research with Aboriginal people. Since Aboriginal people have unique knowledge systems, a research framework informed by their cultural epistemologies was necessary to define the parameters, scope and design of the study. It incorporates two worldviews and is informed by established theory and relevant paradigms. In this chapter, I present a rationale for selecting the key elements that were selected for my theoretical framework and then discuss the integration of Aboriginal and Western paradigms in my research.

Positioning Myself as a Non-Aboriginal Researcher

When I started this research I became aware, through my teaching, professional development and relationships with Aboriginal people, that the way in which knowledge was produced in Australia was not generally inclusive of the Aboriginal perspective. Past mainstream philosophies still underpin many of the current approaches to research, including data collection, methods, analysis, reporting and dissemination of results. I was, therefore, faced with perplexing questions, such as: Are Australian Aboriginal peoples afforded equity in the research process? Can I, as a non-Aboriginal person, speak on behalf of Australian Aboriginal peoples? Is it appropriate for me to use Western research methodologies in my study of a once colonised and marginalised group of people?

I found that these questions were also being asked in academia, especially by Aboriginal authors. Chilisa (2012, p. 130) frames the pertinent questions thus:

- How can we conduct research without using only Western academic constructs and terminologies?

- How can we minimise the intrusion of terms in our research reports that may culturally and contextually lack contingency with our experience? Can academic languages accurately communicate our experiences?
- What is the contribution of our languages, stored in folklore, mythologies, and proverbs, to the building of Aboriginal conceptual and theoretical frameworks and the design of interventions to improve the quality of life of our people?

As I pondered these questions, I became aware of the challenge of producing a thesis that would be authentic, respectful and beneficial to my research participants, as well as my role in providing answers to the research questions. I was aware that I had to examine the post-colonial legacies of research for Aboriginal peoples as well as new paradigms and methodologies that are being proposed. Underlying this examination was the understanding that researchers are knowledge brokers; people who have power to legitimate arguments for or against ideas, theories or practices, and are collectors of information and producers of meaning which can be used for or against Aboriginal interests (Cram et al., 2004, p. 158).

It was important, therefore, for me to consider my position as a non-Aboriginal researcher and to question the use of a purely Eurocentric approach. I looked at the literature available both nationally and internationally and examined what Aboriginal researchers and academics are advocating. What I read indicated that Aboriginal researchers have become disillusioned with the use of traditional positivistic research methods when researching Aboriginal people. These approaches are considered to be damaging, harmful, insensitive, intrusive and exploitative (Davey & Day, 2008; Henry, Dunbar, Arnott, Scrimgeour, Murakami-Gold, 2004; Johnstone, 1991; Maddocks, 1992; Sherwood, 2010). As noted by Manderson et al. (1998, p. 223), past research has, on the whole, involved Western academics descending upon on a community, demanding permission to conduct their work, collecting their data (biological or social) and in the majority of cases, providing little or no feedback. As a result of past practice, Aboriginal people have questioned whether research will address their inequality (Dodson & Smith, 2003; Rigney, 2001; Smith, 1999).

Over the past 30 years, however, literature has emerged with examples and suggestions on how to approach research with Aboriginal peoples. Using these examples of past research, I learnt about possible ways to decolonise research and to ensure that my findings are not constructed through Western hegemony and ideology (Elabor-Idemudia, 2002). Models from both Australia and across the globe have helped me to plan a theoretical and philosophical foundation for my research, including the works of Kahakalau (2004), Chilisa (2011), Wilson (2008), Martin (2003), and Moreton-Robinson and Walter (2009).

My research approach, as advocated by Rigney (1997b), sought to move away from the historical application of colonial research methodologies which have contributed to the marginalisation of Aboriginal community interests. Rather, I embraced Aboriginal research methodologies to ensure the achievement of Aboriginal intellectual sovereignty within research projects. This revisioning of what research should look like for Aboriginal people is important if Aboriginal people are to become masters of their own destiny. In the words of Kath Walker (cited in Moore, 1994, p. xi):

If Black Australians are to become masters of their own destiny, White Australians must recognize them as being capable of formulating their own policy of advancement Black Australians ... must define what is best for their own advancement and then they can determine where White Australians can be of assistance.

The Development of a Research Framework

In this section, I describe the framework involving an Aboriginal research paradigm that was used in this study. The section starts with a narrative that encapsulates my need to work and research in a culturally appropriate manner. I acknowledge that the Aboriginal worldview has its roots in Aboriginal culture, and deem it important to use these values and customs so that Aboriginal and Western worldviews do not clash in this study. I then go on to describe how my framework uses an Aboriginal research paradigm and recognises Aboriginal worldviews and knowledge. With the Aboriginal research paradigm underpinning my research and ensuring ethically sound practice, the Western research paradigms of interpretivism, critical theory and

action research were drawn on to complement the research. Each of these are described in terms of how they are meaningful to the framework of my study.

Narrative: Yarns with Aunty Kay

This narrative was written to illustrate how my dialogue with Aboriginal Elders helped me to formulate my framework.

It is late in the afternoon, the siren has sounded and the last students hurriedly exit through the glass doors, deliriously happy as they head home. School's out! As I pass them, their shrieks of delight and loud chatter are an irrefutable signal that they are ecstatic that the day is over. I too heave a sigh of relief as I walk over to Kay's room. Kay is our teacher, one of the strongest Aboriginal women I have ever met. At the end of the school day we often catch up over a cuppa to discuss the day's highs and lows.

As I enter, she is seated on the couch with a cup of tea. She's a slightly built woman, with olive skin, beautiful brown shoulder length hair, a delicately shaped face, brown soft eyes and a hearty laugh when amused. Her room is a kaleidoscope of colour, reflecting her personality. Every inch of the room is decorated in bold, vibrant Aboriginal colours of black, red and yellow and saturated with Aboriginal quotes, articles and inspirational messages. The quote that always catches my eye when I enter her room is "strong culture strong mind."

It's always a pleasure to enter Kay's room. She never rushes anyone out and takes the time to tell poignant stories, often mingled with anger and pain but superimposed by a strength that suggests that the scars of her past are now the road maps to her future. Her cultural identity of being proudly Aboriginal, combined with her infinite wisdom of the Aboriginal Dreamtime and histories, makes her a valued friend and colleague. She has sparked my interest in trying to explore the idea of embedding Aboriginal perspectives in science.

I sit down and Kay offers me a cup of tea. Immediately her eyes light up as I ask her if she is happy to share with me her thoughts on Aboriginal students' under-representation in science. This is a topic that gets her excited and she eagerly gets into the heart of the matter.

“I don't really think it's one single cause...” she says... “remember astronomy was not discovered by the Greeks. Aboriginal people have studied the night skies some 60,000 years ago as they travelled all over their land. Our dreaming stories reveal information about the stars, planets, the moon and the tides. There is science in our culture and Aboriginal knowledge can contribute to Western modern science by offering our observation and lived experiences”.

She goes on to explain that before colonisation, Aboriginal people had their own number system, used the stars for navigation and knew, before Galileo, that the moon controlled the tides. As a people, they developed their own bush medicine and even had their own Da Vinci in David Unaipon, who lodged 19 patents in his lifetime, tried to accomplish perpetual motion, and conceptualised the helicopter before it was realised.

As she talks, her passion increases, and I sense a feeling of agitation on her part, as she voices her frustration.

“Why aren't our Aboriginal or even the non-Aboriginal kids learning these things in class? Our Aboriginal knowledge must be recognised in the classroom and in the curriculum and not only Western knowledge.”

I lean forward in agreement. Kay has ignited a nagging and persistent theory that has been circling in my head. Like Kay, I have become tired of seeing Aboriginal students struggling in a school curriculum that does not include their culture. Kayleen continues to lament the paucity of attempts to embed Aboriginal culture in the curriculum and strongly calls for a shift in paradigms.

“I do believe that the Aboriginal worldview and the western worldview are both important and should sit side by side for an equitable future for our students.”

She pauses to take a sip of her tea and I ponder on her words, which become my inspiration

My yarns with Aunty Kay and other members of the Aboriginal Consultative Group have helped me to shape my framework, as I sought to represent their thoughts, views and perceptions through my own cultural lens. My ontology and the ontologies of my participants, therefore, come together in this research in a blend of both Australian Aboriginal and non-Aboriginal epistemologies; both of these are valued tenets for my enquiry into the research questions. Whilst I accepted that Western paradigms had a place in society and were used to build the structure of my methodology, I also turned to the new body of knowledge found in Aboriginal paradigms that inform Western research. In the next section, I discuss the Aboriginal paradigms that have been drawn on to build the theoretical structure of this research, and then provide an outline of how a Western paradigm balanced my study.

Aboriginal Paradigm: A Decolonising Framework

The theoretical framework that I have established for this research uses an Aboriginal paradigm to support the embedding of Aboriginal perspectives into the science curriculum, as opposed to the imposition of a purely Western paradigm. The formative guiding principles for the Aboriginal paradigm that I have used in my study are drawn from the work of Karen Martin (2003). Martin is a Noonuccal woman with ancestral ties to Bidjara land in Queensland, Australia. I have chosen her work because she is a culturally strong Aboriginal woman and teacher who has worked in many education roles developing policy and curriculum, and advocates for an education system based on the expressed needs and aspirations of Aboriginal people. Since my work is situated in education, the theoretical framework developed by Martin (2003) for Aboriginal and Indigenous research is a good fit for my study. The principles that she advocates for research with Aboriginal people have formed

the basis of my study, as they confirm that Aboriginal methodologies are a vigorous and active field of knowledge production.

Aboriginal methodologies involve Aboriginal peoples from around the world, including Australia, applying their own lenses, perspectives and understandings to social research, using methodologies which reflect their ontologies (way of being), epistemologies (ways of knowing) and axiologies (way of doing). Demonstrated graphically below in Figure 2.1, the guiding principles from the work of Martin (2003) underpin what is termed a decolonising Aboriginal research framework.

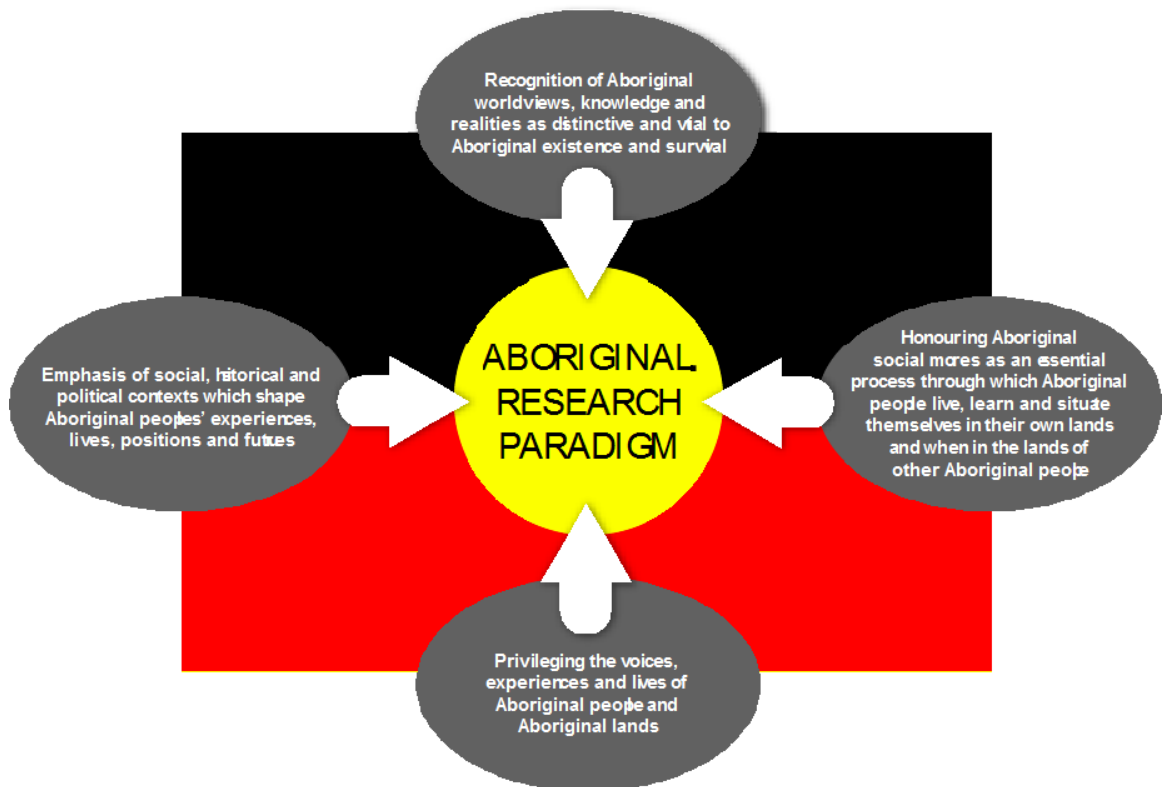


Figure 2.1: Guiding principles for an Aboriginal research framework (Adapted from Martin & Mirraboopa, 2003, p. 2005)

I have used these guiding principles and have also incorporated other prominent works in this field to substantiate them below.

Recognition of Aboriginal Worldviews, Knowledges and Realities

Recognition of Aboriginal worldviews, knowledges and realities in an Aboriginal research paradigm is being increasingly recognised as important to Aboriginal existence and survival (Martin, 2003). The notion of decolonisation is an important one. According to Sherwood, Keech, Keenan and Kelly (2011, p. 194), “decolonisation is a process that requires the positioning of oneself in history and the recognition of ideas and assumptions that have informed one’s worldview.” Research on or about Aboriginal peoples need to be informed by Aboriginal knowledge systems (Battiste, 1995; Chilisa, 2011; Henderson, 2000; Rigney 2001; Smith, 1999). Therefore, my theoretical framework sought to embed an understanding of the cultural norms and values of Aboriginal people, their language, metaphors, stories, legends and folktales, with research methods and measures that were tailored to the cultural group involved (see Chilisa, 2011).

As an example, a simple yet powerful piece of artwork (Artwork 1) locates my framework within my local Aboriginal Consultative Group. Created by an Aboriginal student, it explains how Aboriginal ways of being, knowing and doing can be included into Aboriginal life.



Artwork 1: *Footprints of Change* by Rekeisha Mills

The artwork depicts the Aboriginal Dreamtime and creation stories, symbolised by the snake (known as the Wargle or Rainbow Serpent by the Nyoongar people) below the tree of knowledge. Connecting to the land and oral traditions is depicted as sitting around the fire and sharing stories.

The image illustrates how Aboriginal ways of being, knowing and doing can come to the forefront (in education) and decolonise what is being taught in Western society (depicted by the grey school building). Whilst the grey building represents Western society in the picture, the tree of knowledge and connection to the land in front of the building is more vibrant.

Aboriginal people are sitting at the fire with their traditional spears telling stories, and the arrows show that these stories, although from the past, go forward for the younger generation. The door to the classroom is open, and arrows and footprints point from the Aboriginal cultural ways to the door, asking to be let in. The concentric circles in the drawing show that the pathways are linked, as is the culture, all of which point to reciprocity in an interconnected world. This picture, so evocative in nature, emphasises that research is not "...merely a collection of objects, stories and ceremonies, but a complete knowledge system with its own concepts of epistemology, philosophy, and scientific and logical validity" (Battiste, 2000, p. 19).

Developing my Framework

In developing my framework, honouring Aboriginal social mores was the core principle. Important factors were taken into consideration, including relational ontology, epistemological principles and relational axiology. All of these aspects provide clear guidance on how they can be included in a theoretical framework.

Relational Ontology

Ontology is the belief about reality, your way of being and what you see as real in the world (Wilson, 2001). A relational ontology acknowledges that there are multiple realities. There is growing evidence to suggest that research "needs emancipation from hearing only the voices of Western Europe, emancipation from generations of silence, and emancipation from seeing the world in one colour" (Guba & Lincoln,

2005, p. 212). The research landscape is shifting with the knowledge that, when Aboriginal people are the participants of research, they are more empowered to set the research agenda; therefore a *relational ontology* is important to this study.

My vision was coloured by my own ontology as a Black woman born in South Africa and now as a migrant living in Australia. It is only through relationship building and permission from the Aboriginal Consultative Group that I am able to share the ontology of Australian Aboriginal people, who perceive and understand the world differently.

Wilson (2008) confirms that establishing relationships with Aboriginal people is key to an Aboriginal research paradigm. Discussions with the Aboriginal Consultative Group served to align my thinking to a crucial premise that research with Aboriginal people should be based on their worldviews and systems of knowledge. Further, I was cognisant of the fact that this knowledge, unlike Western knowledge, is perceived to be eternal; in other words, it can be retrieved when needed and recede from consciousness when not required (Cajete, 2000; Henderson, 2000).

Relational Epistemologies

Epistemology refers to how we think about reality (Wilson, 2008). The way that an Aboriginal person thinks or knows about something (culturally-based epistemology) may be different to a non-Aboriginal person's thinking. Significant evidence exists to suggest that individuals and groups go about acquiring new skills and knowledge and come to understand the world in markedly different ways (Appleton, 1983). While there is no gene, or set of genes, which define culturally- or racially-based 'learning styles' and with a great diversity in the socio-cultural experiences and learning preferences of Aboriginal people, there are, however, similar historical, socio-economic and cultural similarities that predispose many Aboriginal students to certain ways of learning and acquiring new skills (Cahill & Collard, 2003; Castagno & Jones Brayboy, 2008; Gardner & Mushin, 2013; Hughs, Moore and Williams, 2004; Pegg & Graham, 2013). There is, according to Craven, Bodkin-Andrews and Yeung (2007, p. 4), a need for empirical evidence to "tease out facets of quality teaching that are salient to Aboriginal students; elucidate their perspectives of teacher

quality; and test the influence of specific facets of quality teaching on academic outcomes and the consequences of the findings for developing interventions for Aboriginal and Torres Strait Islander students.”. In Australia, the Aboriginal Ways of Learning Project (Hughes, More & Williams, 2004) found that there were patterns in the strengths that Aboriginal students demonstrated with respect to the ways in which they learned; and Aboriginal cultures appeared to have a strong influence on these patterns.

For example, some Aboriginal people have been found to prefer a holistic approach to knowledge, valuing the process more than the knowledge itself (Christie, 1997). Further, teachings are transmitted from generation to generation through storytelling. These stories, which are alive with the nuances of the storyteller, emerge from traditional languages that emphasise verbs and are garnered through dreams and visions (Hart, 2010). Aboriginal epistemologies are likened to perceptual experiences (Hart, 2010).

Finding out how Aboriginal people live, learn and situate themselves (Martin, 2003) is important, as early colonisers of Australia who arrived with a Western worldview did not understand Aboriginal culture. They thus destabilised this traditional knowledge by imposing their own systems of law, knowledge and worldviews (Partington, 1998; Reynolds, 1982). The Aboriginal way of thinking about reality is experiential, but this was not recognised, and no attempt was made to respect cultural relevance and cultural safety (Hagen and Huisjer, 2008). Embedding relational epistemologies in my framework allowed for a connection between the Aboriginal and Western paradigms. In doing so, Aboriginal knowledge, context and values were viewed in relation to the positive aspects of a Western context.

Relational Axiology

Including a relational axiology in my framework ensured that I worked within a set of morals, values and ethics (Wilson, 2008). I was also guided by the Australian Code for the Responsible Conduct of Research (National Health and Medical Council, 2007) which includes the principles of spirit and integrity, reciprocity,

respect, equality, survival, protection and responsibility, as explained in Chapter 4. These values are endorsed by Weber-Pillwax (2001, p. 168) who states that:

I could make a value statement and say that whatever I do as an Indigenous researcher must be hooked to the community or the Indigenous research has to benefit the community The research methods have to mesh with the community and serve the community. Any research that I do must not destroy or in any way negatively implicate or compromise my own personal integrity as a person, as a human being.

The four main elements of a relational axiology included in this study are relational accountability, respectful representation, reciprocal appropriation, and rights and regulation.

The first principle, *relational accountability*, took into consideration the connectedness of the Aboriginal people to the land and to the Dreamtime, a concept that encompasses the cosmic set of relationships that originated from their spirit ancestors during creation. My use of Aboriginal research methodology (Kovach, 2009; Louis, 2007; Smith, 2013; Wilson, 2008), and yarning as a research method (Bessarab & Ng'andu, 2010; Franks et al., 2001; Fredericks et al., 2011; Geia, Hayes, & Usher, 2013; Goulding, Steels, McGarty, 2016) ensured that my research was connected to the theory of knowledge in Aboriginal culture.

By including and acknowledging Aboriginal histories, narratives and social practices and rituals (mythology), and positioning the Aboriginal Consultative Group as major stakeholders in the research, I provided important avenues for knowledge transmission and incorporating Aboriginal voices (Absolom & Willett, 2004; Smith, 2000; Steinhauer, 2002). As an important consideration in this study, I sought to empower them as owners within the research through collaboration and inclusion, as recommended by Howitt and Stevens (2005). As a result of deliberately involving my participants, the nature of my research changed and became more meaningful.

The second principle central to my research was that of *respectful representation*. This principle relates to how the researcher respects herself, the research participants,

and the events being researched. This respect is required to be a genuine gesture, rather than tokenistic, and should, according to Louis (2007), demonstrate humility, generosity, and patience with the process by accepting decisions of the Aboriginal people in regard to the treatment of any knowledge shared. In my study, this principle involved including the voices of the Aboriginal Consultative Group and the students as an important part of de-centralising the Western paradigm and legitimising the Aboriginal epistemological, ontological and methodological perspective.

The third principle, *reciprocal appropriation*, refers to the dual nature of the research that includes benefits for both the Aboriginal people and the researcher (Johnson & Murton, 2007). Throughout my research, I avoided making this research just my own by involving the local Aboriginal community partners on a journey intended to make a difference to their children in the educational world. Further, I sought to share the results of the study and the methodology both nationally and internationally at Aboriginal education conferences.

In ensuring that the research benefitted all participants, I upheld the fourth principle, advocated by Loius (2007), of *rights and regulation*. In upholding this principle, I made sure that the research process was determined by and sought to empower the local community and was not driven by personal gain. At each stage of the research, consideration was given to how the research would impact on the research participants and the Aboriginal community. By establishing an Aboriginal Consultative Group, I was better able to bring the rights of Aboriginal people to the fore and protect the intellectual property of the local Nyoongar community as owners of the knowledge.

Using the Third Space to Underpin the Framework

A core component of my framework, as advocated by Martin (2003), is the privileging of Aboriginal voices, life experiences and their lands. Research carried out using Aboriginal methodologies and involving Aboriginal voices ensures the insiders' view — “how Black people themselves perceive and understand their condition” (Langton 1981, p. 16) – is perceived and respected.

Privileging Aboriginal voices in research when Aboriginal and non-Aboriginal people are involved can be promoted through a theory of cultural interface or working in a third space, which promotes a practical and culturally appropriate way to establish a middle ground. In this research, third space or a cultural interface (Martin, 2009; McLaughlin, 2012; Nakata, 2002; Nakata, Nakata, Keech & Bolt 2012; Yunupingu, 1989) involves finding a cultural space where Western and Aboriginal domains intersect. The concept of third space was first developed by Bhabha (1994) as a metaphor for the space in which cultures meet, colonial authorities are challenged and hybrid identities created. In my study, however, I draw on the third space concept advocated by McLaughlin (2012).

The notion of Third Space hybridity as developed by Bhabha, (1994) from literary and cultural theory describes the construction of culture and identity as the process by which the colonisers translated the identity of the colonised (the Other) within a singular universal framework but then fails to produce something familiar but new. This concept of a third space is challenged by Aboriginal academic Scott Fatnowna (unpublished) who explains that the third space that Nyoongar people occupy involves coming together and moving ahead (McLaughlin, 2012). The difference between Scott Fatnowna's Third Space and Homi Bhabha's notion of hybridity is that the Fatnowna version is an Aboriginal form of Third Space and hybridity does not come into it at all. As such, Scott Fatnowna's model of third space is an equitable model designed to initiate positive change between Aboriginal Australians and non-Aboriginal Australians through understanding each other's worldview by working and learning together with equal power and cross-cultural dialogue (McLaughlin, 2012).

My research embraces this view, as it allows Aboriginal and non-Aboriginal people to cross multiple cultural borders, and is designed to inspire positive exchange between Aboriginal and non-Aboriginal Australians. This is facilitated through working together and developing mutual understandings of each other's worldview, with equal power and cross-cultural dialogue (McLaughlin, 2014).

The implications of the third space in my theoretical framework are numerous:

1. The third space allowed Aboriginal and non-Aboriginal research participants to share personal experiences in an impartial setting which was not owned by either party. Each person was exposed to various forms of cultural differences but used this as a way to experience personal growth.
2. The third space allowed me to develop a theoretical and methodological framework for my study that equally represented two worldviews.
3. The third space accepted and valued the identity of each research participant and provided a safe space for each of them to work together.
4. The third space allowed all research participants to ask questions, challenge assumptions and create new ideas.
5. The third space facilitated relationship building and collective actions between Aboriginal and non-Aboriginal people. It moved the 'us' and 'them' thinking to the 'we' thinking, thus making the space a place for collaboration and new learning.
6. The third space practice recognised the unique Aboriginal and Torres Strait Islander histories, perspectives; ways of knowing, being and doing (Martin, 2009) and at the same time maintained the best practice found in appropriate Western ways of knowing, being and doing.
7. The third space served as a form of reconciliation and social justice (Shiza, 2010) as both Aboriginal and non-Aboriginal students worked side by side on various activities.
8. The third space created a culture of value and acceptance for all research participants.
9. Locating and charting a Third space for both Aboriginal and non-Aboriginal people in which their worldviews can cross over as a place of intersection (McLaughlin, 2012), promoted a spirit of cooperation and collaboration.

In summary, after critical evaluation of current thought and best practice to develop a culturally relevant and appropriate theoretical framework, I sought to develop such a framework for my study. As such, I adopted an Aboriginal paradigm within a decolonising framework. It consists of four elements: emphasis on social, historical

and political contexts which shape Aboriginal peoples' experiences, lives, positions and futures; recognition of Aboriginal worldviews, knowledges and realities as distinctive and vital to Aboriginal existence and survival; honouring Aboriginal social mores as essential processes through which Aboriginal people live, learn and situate themselves in their own lands; and, when in the lands of Aboriginal people as a researcher, privileging their voices, experiences and lives. I was satisfied that this framework would be acceptable to the Aboriginal research academy.

Inclusion of Western Paradigms

Historically, research that involved Aboriginal people has been developed out of and based on Western research paradigms. Aboriginal paradigms and Aboriginal ways of carrying out research have emerged over time, with some Aboriginal researchers relying solely on Aboriginal methodologies. In my research, in conjunction with Aboriginal paradigms (which enabled me to carry out my research in a respectful and ethically sound manner from an Aboriginal perspective), I drew on three Western paradigms: interpretivism, criticalism and action research. It was important that I wove these Western paradigms into the Aboriginal ways of knowing, being and doing, as it allowed me to acknowledge the humanistic nature of the different cultures, as discussed below.

Interpretivism

Interpretivism emerged within the social sciences in opposition to positivism. From an interpretivist perspective, reality is socially constructed and, as such, there are as many intangible realities as there are people constructing them (Creswell, 2009; Creswell & Clark, 2011). Interpretivism allows for a range of views and realities (including the myths we live by). The interpretive paradigm espouses a relativistic view of the social world and, as documented by Howell (2012) and Stryker (2002), "reality-meaning is not considered as independent from human consciousness but is the negotiated result of [an] individual's interpretations of the world." Interpretivism, therefore, is based on the belief that people carry out actions in a culturally-specific way which may not be universally understood.

Adopting an interpretive approach allowed me to understand the lived experiences of Aboriginal people from their point of view, and how these experiences could shape Aboriginal students' engagement in science. Using the guidelines provided by Angen (2000), the interpretivist approach allowed me to carefully and respectfully articulate my research questions, to carry out an inquiry in a respectful manner, and to demonstrate evidence of taking responsibility for the choice of my interpretations. To evaluate the substance of the interpretive approach that I adopted, my results were evaluated and the validity was located in the discourse of the research community. Both ethical and substantive validity were recognised (Reeves & Hedberg, 2003).

The interpretive approach allowed me to examine Aboriginal students' engagement in science and the meaning that they attributed to their disengagement. Given that in the interpretivist approach, reality is relative (Guba & Lincoln, 1989), complex, difficult to interpret, and dependent on other systems for meanings, this approach gave me the ability to recognise that cultural positioning is different and that this difference should not be devalued and is central to this research.

By incorporating an interpretivist view into my theoretical framework, I was able to argue that Aboriginal students have a distinct way of carrying out their everyday duties in life and that these are determined by their personal belief systems. When Aboriginal students set foot in a predominantly Western school, they bring with them their own reality, which is grounded in a socially constructed, rich and unique culture. This reality is different to the syllabus orientation of the White Australian profile. Therefore, using the interpretive approach was ideally suited, as it:

...engages both the 'hows' and the 'whats' of social reality; it is centred both in how people methodologically construct their experiences and their worlds and in the configuration of meaning and institutional life that inform and shape their reality-constituting activity. (Gubrium & Holstein, 2000, p. 488)

My study also involved participant observation. I drew on naturalistic observations and yarning with the Aboriginal Consultative Group (the students and teacher) to establish dialogue and to collaboratively construct a meaningful reality from the

research process. According to Erickson (1986), humans create meaningful interpretations of the physical and behavioural objects that surround them in the environment, as knowledge is not gained in only one particular way within one correct theory (Walsham, 1993; Willis, 1995). These views helped me to convert my research into a diverse array of interpretations.

Critical Theory

My study also drew on critical theory. This was a natural choice for working within an Aboriginal research framework as it enabled me to expand on the complex issues surrounding Aboriginal knowledge. Critical theory has been used in Aboriginal research to challenge historically biased views and for its “promise of overcoming ‘dominant’ power relations and delivering ‘empowerment’ to Indigenous people on the ground in the form of practical action in Indigenous interests” (Nakata, Nakata, Keech, & Bolt, 2012, p. 124).

My use of critical theory as part of my research framework helped me to overcome the historical domination of Western theory in Aboriginal research. Drawing on the critical theory paradigm helped me to contextualise the political, cultural, economic and social relationships within Aboriginal cultures and provided a point of reference when exploring what level of power students have over the ways in which they learn science. Critical theory argues that science is not value-free and that it can be viewed in the context of the political, ideological and cultural assumptions of Aboriginal people. Critical pedagogy, according to Giroux (1992, p. 74), provides:

... Students with the opportunity to develop the critical capacity to challenge and transform existing social and political forms, rather than simply adapt to them. It also means providing students with the skills they will need to locate themselves in history, find their own voices, and provide convictions and compassion necessary for exercising civic courage, taking risks.

Using a critical theory approach sought not only to understand the issue that exists but involved a process for equitable change. As a critical theory researcher, my challenge was to promote change in Aboriginal education (Hoy & McCarthy, 1994),

and to build a case for the inclusion of Aboriginal perspectives in the curriculum as a means of engaging more Aboriginal students in science.

Conclusion

I acknowledge that although I have read and continue to read extensively about how to include Aboriginal and Western paradigms into research, there may be other ways of doing this, and I continually strive to increase my knowledge in this field. My work attempts to track this process in its contribution to this emerging field, so that, as recommended by Denzin (2005, p. 1122):

... non-Western, Indigenous and 'coloured' epistemologies' will contribute to the creation of a vital mix of new paradigmatic perspectives, new methods and strategies for research, contested means of establishing validity in texts, new criteria for judging research and scholarship, and competing cosmologies from which knowledge and understanding might grow.

I see this approach, not as a challenge to Western research paradigms but, rather, as an opportunity for innovation. I have not negated the influence or positive contribution of Western ways of carrying out research but, rather, I have crafted a framework that encompasses Aboriginal and Western scientific knowledge as a complementary rather than a conflicting system of knowledge, where Aboriginal people are given a space to work with a researcher in the design and development of research which empowers them in the journey to self-determination.

Chapter 3

Literature Review

In this chapter, I review the literature pertinent to three key areas surrounding the embedding of Aboriginal perspectives in the science curriculum. In the first part, I provide a brief review of the education of Aboriginal students in Australia, as an important basis for understanding why Aboriginal students continue to experience disappointing educational outcomes compared to their non-Aboriginal peers. In the second part, I review literature that addresses this disparity, particularly in science, between Aboriginal and non-Aboriginal students. Finally, in the third part, I review literature related to embedding Aboriginal perspectives into a culturally responsive curriculum and its impact on Aboriginal student outcomes.

Part One: A Brief History of the Education of Aboriginal Children in Australia

This section provides a brief review of the colonial system of education in Australia and identifies the key features of policies that were established. From 1790 to 1890, the Australian colonies developed from being one penal settlement in New South Wales to six sovereign colonies, each of which established its own system of governance (Shorten, 1996). This review, therefore, covers the generic education provided across the colonies, with some emphasis on Western Australia, where the research described in this thesis was carried out.

The history of colonial education provides insights into the intergenerational influences on Aboriginal students' educational achievements of the present day. It has been argued that past policies, actions and attitudes toward Aboriginal people in Australia have generated intergenerational disadvantages, both educational and social (Beresford & Partington, 2003; Keddle, Gowlett, Mills, Monk, & Renshaw, 2013).

This section reviews some of the literature related to the education of Aboriginal students from the early colonial years up to the present in five parts: the initial “civilisation” of Aboriginal students, education provided by missionaries, The Protection Period, The Assimilation Period, and the movements for change.

Civilising Aboriginal Children

When European settlers arrived in Australia, Aboriginal people were generally viewed as savage, uncivilised and living in miserable conditions (Brantlinger, 2003; Griffiths, 1996; Hiatt, 1996; McGregor, 1997). The education afforded to Aboriginal people during early colonisation was minimal, and the aim of education was to socialise them into the Western culture. The education provided to Aboriginal students equated to the standards expected of a ten-year-old Western child. As Loos and Osanai (1993, p. 20) observe:

What education was provided generally aimed at completion of their schooling at the level achieved by a ten-year-old child in the State education system. It emphasised domestic science and manual training, thus preparing the children for a future as menial workers within the government or mission communities or as cheap labour in the wider community.

In the majority of cases, Aboriginal male students were prepared for manual labour, while female students were schooled in ways of being of service to the settlers (Brook & Kohen, 1991; Read, 2006). It is generally agreed that the low level of education given to students was because many did not view Aboriginal people as possessing the necessary intellect to learn beyond this level (Brook & Kohen, 1991). According to Read (2006), the curriculum was generally watered down and taught by unqualified teachers. Eileen Morgan, renowned Aboriginal author, recalls this system from her school days at Wallaga Lake in New South Wales:

We never learned too much because Mr Sampey was always being called out The older girls or boys would take the tiny ones down the front ... and read a story to them or ask them to spell. That was done mostly every

day because he was always away. Later I discovered that managers like Mr Sampey were not trained teachers. (1994, p. 54)

The first school for Aboriginal students was established by Governor Macquarie in 1814. Beresford and Partington (2003, pp. 41-41) state that the purpose of these schools was to “civilise the Aboriginal population away from the tribal customs (and land) by inculcating Christian habits and the wider values of Europeans.” For many Aboriginal students their experiences of school were coloured with feelings of being caught in a system that did not value them, as portrayed in a narrative by an Aboriginal student cited by Barker & Matthews (1988, p. 56):

School started in early February, and I shall never forget my first day. Billy and I sat together both feeling very nervous. It was on this day that I learnt how unacceptable Aborigines are to other people. The manager [Scott] told us straight out that we were just nothing He said it was not much use trying to teach us and that he wanted to make it clear that it was a complete waste of time. I had never before encountered the cruelty and brutality which surrounded us here, and it was a shock to find that this could occur.

After this initial period, the schooling system for Aboriginal students then extended to what is known as the mission period, during which the European colonists encouraged the arrival of missionaries into Australia to assist with the civilisation of the Aboriginal people (Beresford & Partington, 2003).

Mission Education

Missionaries travelled to Australia from Europe to “save” and educate Aboriginal children. According to Harris (1990), the first missionary presence in Australia was the Wesleyan Missionary Society, which arrived in 1821. In reviewing the role of mission education in Australia, my purpose is not to judge whether missionaries reinforced the ideology of European colonists and eroded Aboriginal cultures, but to present an objective view of the education that Aboriginal children were given and how this impacted on future generations.

Missionaries acted as a de facto arm of the colonial government (Smithers, 2009). Their main purpose was to help to prepare the Australian frontier for settlement. In many cases, the missionaries held low perceptions of the Aboriginal people, often applying evolutionary theories to describe them. For example, Wesleyan missionary Samuel Leigh described Aboriginal people as “barbarians to whom had been assigned the lowest place in the scale of intellect”; and William Schmidt of the Lutheran missionary stated that Aboriginal people were “the lowest in the scale of the human race” (cited in Harris, 2013, p. 29). As a result of these views, the early missionaries maintained a social distance between themselves and the Aboriginal people, whom they regarded as their inferiors, and worked instead towards inculcating Western and Christian values into the children under their control (Harris, 2013).

In trying to change the Aboriginal way of life, some missionaries forcibly removed children from their parents. The reasoning behind this removal was articulated by missionary Hoerlein of Bloomfield (cited in Loos, 1975, p. 50): “our hope is centred on the young people. The older people are too set in their nomadic ways.” Children who were removed from their parents were housed at the missions in dormitories. They were exposed to highly organised, supervised daily programs, removed from their traditional influences, and given schooling based on European–Christian values. For the most part, their education involved learning skills in carpentry, agriculture, basket making, and home craft (Fletcher, 1989). Some children were taught to play musical instruments and to sing in the choir.

Missionary education allowed Aboriginal children access to certain aspects of European life whilst denying them access to the intellectual, social and scientific fields of knowledge (Loos, 1975). The consistent theme in mission education was the limited and inferior curriculum that was administered to Aboriginal students. This disadvantaged Aboriginal people in two ways. First, the teaching in mission schools undermined Aboriginal children’s language and culture, and second, it established the gap between Aboriginal and non-Aboriginal outcomes which is still evidenced today (Hohepa & McIntosh, 2017; Phillips & Luke, 2017; Prout Quicke & Biddle, 2017).

Despite the negative reports of missionary education, there were some positive influences. According to Noel Loos (2007), some missionaries learnt and recorded Aboriginal languages for preservation and advocated that land ownership must be granted to Aboriginal people. Further, it is acknowledged that Christian missionaries have since changed their way of working with Aboriginal people and, more recently, have assisted in the restoration of Aboriginal culture in the process of reconciliation (Loos, 2007). For example, Ernest Gribble, an Anglican missionary, played a key role in uncovering the Forrest River massacres, leading to a Royal Commission investigation (Loos, 2007).

Mission education was replaced when the Board for the Protection of Aborigines and the *Aboriginal Protection Act 1869* (Vic) were introduced with the aim of controlling and managing the interests of Aboriginal people. The Protection Period, as it became known, is reviewed in the next section.

The Protection Period

The Protection Period was viewed by the Australian government as a benevolent policy to protect Aboriginal people from extinction (Attwood & Markus, 1999). Instead, however, the Protection Act controlled where Aboriginal people could live, where they worked and whom they married. With the introduction of this act, the Government had the power to forcibly remove children from their families and to place them in reformatories or industrial schools (Armitage, 1995). The ideology fundamental to this era was that, if Aboriginal Australians could adopt the values and behaviours of non- Aboriginal Australians, they would be accepted into the majority society. Education was seen as the vehicle for this process. Tatz (1969, p. 6) explains:

The fundamental assumption is that the Australian state educational systems and their values should be taught to Aborigines: one must teach the Aborigine how to become a White Australian, then teach him a trade, and then expect achievement in the White Australian sense of the term.

In 1905, the *Aborigines Act 1905* (WA) was introduced. The act extended the government protection and allowed the removal of half-caste children from reserves. This act made the Chief Protector the legal guardian of every Aboriginal and “half-caste” child under the age of 16 years. It was reasoned that this act was necessary because Aboriginal parents were incapable of raising their children and that it provided them with appropriate education (Armitage, 1995). Through this government policy many Aboriginal children, particularly half-caste children, were forcibly taken from their parents and placed in White (sic) institutions. The children removed during this era became known as the Stolen Generations, and this act is regarded as one of the most negative consequences of colonisation (Dudgeon et al., 2014, p. 12). The act was found to be in breach of binding international law and, according to Dudgeon, Wright, Paradies, Garvey and Walker (2010), not one Aboriginal person could be said to have been untouched by this legislation after it was implemented across the country.

Education during The Protection Period was similar to that provided during the Mission period, with boys being prepared for manual labour and girls for domestic work. Aboriginal children were considered to have low mental capacity and, at the age of fifteen, were moved out of the institutions into apprenticeships or the workplace (Read, 2006). “Anything above ‘average’ was rare (in school reports) and the majority of comments ranged from ‘poor’ to ‘moronic’” (Read, 2006, p. 15). Dr Mariah (as cited in Giscombe, 2007, p. 172), remembers teachers undermining her intelligence and encouraging her to drop out of school:

... when I was at school (integrated elementary and high schools), and the teachers when I went through college ... were trying to get me to drop out ... [they] said to me, Blacks cannot do science, Blacks cannot do math, and you might as well just give up now and go do something else because, you’re not going to be able to do this One teacher in ... College told the Black kids in that class that they would never make it in the sciences and that they should not even bother to take any science courses.

This disregard for Aboriginal students’ mental capacity continued into the next period in Australian history, referred to as The Assimilation Period. During this

period, the Australian government adopted a new policy designed to help to integrate Aboriginal students into White (sic) society.

Assimilation Period

During this period, which overlapped with The Protection Period, education was viewed as the vehicle through which the Australian government could assimilate Aboriginal children into White (sic) Australian society. In a bid to encourage Aboriginal children to behave like White (sic) people, a policy of assimilation was instated (Read, 2006). Reynolds (1972, p. 175) describes it thus:

The policy of assimilation means that all Aborigines and part-Aborigines are expected to attain the same manner of living as other Australians and to live as members of a single Australian community, enjoying the same rights and privileges, accepting the same customs and influenced by the same beliefs as other Australians.

The government justified this policy as a vision of a modern, racially harmonious nation that promised uniformity of lifestyle, equality of opportunity and the eradication of race-based discrimination (Haebich, 2002). This period (1930 to 1970), has more recently been viewed as a deliberate, systematic effort to train and educate Aboriginal children and to break down traditional Aboriginal practices (Armitage, 1995).

Murawari author Jimmy Barker (Human Rights and Equal Opportunity Commission (HREOC), 1997, Section 10, p. 11) remembers his schooling at Brewarrina in New South Wales during this period:

It was drummed into our heads that we were non-Aboriginal. I was definitely not told I was Aboriginal We hardly saw any visitors None of the other kids had visits from their parents. No visits from family. The worst part is, we didn't know we had a family.

Terry Ngarritjan-Kessarlis (1995, p. 1) reflects on her schooling as an Aboriginal child attending an urban school in Darwin, Australia:

Not once during my twelve years of formal schooling did any of my teachers or anyone else in the school system affirm my Aboriginality. Instead I grew up feeling ashamed of my Aboriginal heritage and I felt pressured to stress that I was only part Aboriginal.

Education during The Assimilation Period included teaching Aboriginal children the Christian belief system, conforming to gender roles, and using non-Aboriginal technology (MacDonald, 1995). Towards the end of The Assimilation Period, the policy struggled to distance Aboriginal people from their traditional beliefs and practices. Further, White (sic) Australians did not generally accept Aboriginal people as equals, and there was widespread racism (Broome, 1982). For example, White (sic) parents often refused entry to Aboriginal students at school, claiming that they were dirty and unhygienic. By 1964 it became clear that Assimilation was flawed on a number of fronts. Aboriginal protest movements began to campaign for the self-determination of Aboriginal people. The Federal Government came under pressure to make changes to accommodate these demands.

Tides of Change

In 1972, Gough Whitlam, then Prime Minister of Australia, set up the Department of Aboriginal Affairs and committed to a policy of self-determination for Aboriginal people. This policy recognised that Aboriginal people had the right to be involved in many decisions related to their own lives (Reynolds & Dennett, 2002). During this period, attempts were made to include Aboriginal languages and culture in education and, in that same year, the first Aboriginal teachers' aides were employed in schools where there were significant numbers of Aboriginal students. Under this new policy, schools were no longer allowed to refuse entry to Aboriginal children.

In 1970, the Aboriginal Secondary Grants scheme was initiated to support Aboriginal and Torres Strait Islander students' retention at high school. More policies followed which aimed to increase the retention of Aboriginal people in education. These included the 1989 National Aboriginal and Torres Strait Islander Education Policy, the 1989 Aboriginal Mentor Program, and the 1990 establishment of The Aboriginal

and Torres Strait Islander Commission (ATSIC). All of these policies were developed to aid the move towards Aboriginal self-determination and autonomy.

In 1991, a Royal Commission into Aboriginal Deaths in Custody reviewed past government policies, including what had become known as the Stolen Generations. As a result of the Royal Commission, recommendations were made to accelerate access, participation and outcomes for Aboriginal people. Subsequently, the Council for Aboriginal Reconciliation was established to foster positive relations between Aboriginal and non-Aboriginal Australians. A Going Home Conference was held in 1994, which offered Aboriginal people the opportunity to share their stories and uncover the history of the removal of Aboriginal children and their families.

In response to the hurt and injustices experienced by Aboriginal people over the years, the 26th of May 1998 was declared National Sorry Day, to be commemorated annually. Aboriginal people sought a formal government apology for past policies and for the forced removal of Aboriginal children from their families. After many protests and much lobbying by Aboriginal people and their supporters, on February 13, 2008, the Federal Parliament apologised to the stolen generations for the injustices of the past. In the apology, Kevin Rudd, then Prime Minister, apologised on behalf of all Australians for the laws and policies which inflicted pain, suffering and loss on the Stolen Generations of Aboriginal peoples (Lane, 2009). The National Apology, viewed as the first official step towards acknowledging two centuries of dispossession, led to a series of policies which advocated and supported change in the Aboriginal arena (Lane, 2009).

Education became one of the main objectives in the new policies targeting change. The National Aboriginal and Torres Strait Islander Education Policy (AEP) of 1989 was a major policy. AEP had four important long-term goals:

1. Involvement of Aboriginal and Torres Strait Islander people in educational decision-making
2. Equality of access to education services
3. Equity of educational participation

4. Equitable and appropriate educational outcomes. (Commonwealth of Australia, 1995)

The goals outlined in the AEP, however, failed to recognise the wider social milieu affecting Aboriginal students as a result of institutional, historical and socio-economic factors (Department of Employment, Education, Training and Youth Affairs, 1995). These factors were reviewed by a Taskforce on Indigenous Education in 2000, and the report of the Ministerial Council on Education, Employment, Training and Youth Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA) was produced; it highlights the broader disadvantages outside of educational disadvantage, providing goals to improve educational outcomes (MCEETYA, 2000b).

Many subsequent policies were passed relating to Aboriginal education in each state in Australia, with the Council of Australian Governments (COAG) now responsible for developing and monitoring the implementation of policy in Aboriginal education nationally (Mellor & Corrigan, 2004). These policies have resulted in a range of Aboriginal-specific education programmes across Australia, which are slowly bridging the gap between Aboriginal and non-Aboriginal educational outcomes.

Some examples of these programs (Commonwealth of Australia, Department of the Prime Minister and Cabinet, Closing the Gap Prime Minister's Report 2017) include:

- The Home Interaction Program for Parents and Youngsters
- The Stronger Communities for Children program
- Families as First Teachers
- The Follow the Dream Program, Department of Education, Western Australia,
- the Aurora Project
- the Australian Government's School Languages Programme (SLP).

To date, however, the gap still exists, and the engagement of Aboriginal students in education continues to be a concern, in particular in science (which is the focus of this study).

Part Two: Australian Aboriginal Educational Achievement in Science

To contextualise the issues related to the engagement of Aboriginal students in science, this section reviews the results of Australian Aboriginal students in international and national science tests. The section goes on to review literature related to the barriers faced by Aboriginal students, to help to explain these trends.

Aboriginal Students' Science Performance

In science, Aboriginal students around the world continue to be under-represented in secondary and tertiary sciences (Aikenhead & Elliott, 2010; McLisky & Day, 2004; Kannankutty, 2008). The performance of Australia's Aboriginal students in national and international science tests follow similar trends, as documented in three major science tests:

- The Programme for International Student Assessment (PISA)
- The Trends in International Mathematics and Science Study (TIMSS)
- The National Year 6 Science Test.

As a means of examining Aboriginal students' performance in science, the results of these three tests are outlined below.

Programme for International Student Assessment (PISA Testing)

The Programme for International Student Assessment (PISA), developed by the Organization of Economic Cooperation and Development (OECD) (Thomson, De Bortoli & Buckley, 2013), is an international standardised assessment of the performance of 15-year-old students in mathematics, science and reading. PISA is administered on a cyclical three-year schedule. Testing started in 2000 which focussed on reading, followed by mathematics in 2003 and a science focus in 2006. PISA assesses three broad science competencies:

- Identifying scientific issues; requiring students to recognise issues that can be explored scientifically and to recognise the key features of a scientific investigation.

- Explaining phenomena scientifically; requiring students to apply knowledge of science in a given situation to describe or interpret phenomena and predict changes using scientific evidence.
- Interpreting evidence to draw conclusions; evidence is interpreted to draw conclusions, to explain them, to identify the assumptions, evidence and reasoning that underpin them, and to reflect on their implications. (Thomson, De Bortoli & Buckley, 2013)

PISA draws each country's sample so that it is statistically representative of the total number of students enrolled in different types of schools (e.g., private, public, college preparatory or vocational schools). In addition, locations are also factored in (e.g., urban or rural). In the 2006 science testing, the Australian sample included 356 schools and over 14,000 students representative of the population of 15-year-old students across the country. Of this sample, 1,080 participating students identified themselves as Indigenous Australians.

The results for all PISA testing cycles from 2000–2012 indicate that Australia's Aboriginal students perform at a lower level than their non-Aboriginal counterparts. The PISA scores for these years, reported in Table 1, indicate that 40% of Aboriginal students performed below the OECD baseline and were considered to be at serious risk of not being able to participate adequately in the twenty-first century workforce or to contribute, in the future, as productive citizens (Thomson, De Bortoli, & Buckley, 2013).

Thomson, De Bortoli, and Buckley's (2013) conclusion is questionable, as Aboriginal education is characterised by a diversity of lifestyles and geographic locations, differing histories of engagement with non-Aboriginal Australia, and a wide spectrum of aspirations for development. Not being able to pass standardised tests does not necessarily mean that these students will not be productive and contribute positively to society. Further questions have always surrounded the validity and fairness of assessment for Aboriginal students (Berlack, 2001; Klenowski, 2009) and whether these tests are culturally appropriate. Given the

unique culture of Australia’s Aboriginal people and the continuing effects of disadvantage, one needs to evaluate these tests in light of legacies of the past.

Further, the results over five PISA cycles (see Table 3.1) indicate that Aboriginal students did not improve over this period (Thomson, De Bortoli, & Buckley, 2013). These results indicate that the gap between Aboriginal and non-Aboriginal students in science achievement has not been narrowed, leaving Aboriginal students performing approximately two-and-a-half years behind their non-Aboriginal peers (Thomson, De Bortoli & Buckley, 2013).

Table 3.1: Mean science scores for each PISA testing cycle: 2000, 2003, 2006, 2009 and 2012

Student Group	2000	2003	2006	2009	2012
Aboriginal	448	434	441	449	440
Non-Aboriginal	529	527	529	530	524
Australians	528	525	527	527	521
OECD Average	500	500	500	501	501

Of interest to this study is that the PISA results suggest a difference in the learning strategies, learning preferences and behaviours of Aboriginal students when compared to non-Aboriginal students (Thomson, De Bortoli & Buckley, 2013). Aboriginal students were found to demonstrate less preference for a competitive learning environment and be more likely to use elaboration and control strategies. Further, De Bortoli and Thomson (2010) examined the contextual factors that influence the achievement of Aboriginal students in science in terms of their attitudes, engagement, motivation and beliefs. They found that Aboriginal students reported a lower interest in and appreciation of science from both a general and a personal perspective compared to non-Aboriginal students. Aboriginal students were found to have significantly lower levels of instrumental motivation in science and lower levels of confidence in their ability to handle tasks effectively. Finally, Aboriginal students reported lower levels of self-efficacy (both in general terms and

in relation to science) and lower levels of self-concept in science than their non-Aboriginal counterparts (Thomson, De Bortoli & Buckley, 2013).

The results for the five PISA testing cycles highlight the need for well-targeted initiatives to shift this impasse. Some of the recommendations cited by Thomson, De Bortoli and Buckley (2013) that are pertinent to this study are: school reform; greater cultural competency; tailored student support services; teacher quality; appropriate assessment and pedagogy; a learning environment that is responsive to individual needs; and involvement of the Aboriginal community in planning and providing education. My study draws on these findings, especially in regard to cultural competency and involving the Aboriginal community in the planning curriculum.

Trends in International Mathematics and Science Study (TIMSS)

The Trends in International Mathematics and Science Study (TIMSS) is, like PISA, a standardised test. The TIMSS test was established in 1995 as a project of the International Association for the Evaluation of Educational Achievement (IEA). It consists of a series of international assessments of mathematics and science, with testing taking place every four years. The results for the testing cycles 1995, 1999,¹ 2003, 2007 and 2011 are reported in Figure 3.1. The results of all five cycles of TIMSS indicate that non-Aboriginal students outperformed their Aboriginal peers for every cycle.

TIMSS also examines student attitudes to learning science using a series of statements such as: I usually do well in science; science is more difficult/harder for me than for my classmates; science is not one of my strengths/I am just not good at science. According to Thomson, McKelvie and Murnane (2006, p. 34), Aboriginal students responded more negatively than positively to these statements when compared to non-Aboriginal students.

¹The 1999 TIMSS assessment was only a partial replication of TIMSS 1995. Internationally only the upper year levels were tested, and the design in Australia was such that it is not comparable with data from other cycles.

The results of both PISA and TIMSS show little progress in terms of closing the gap between the performance of Aboriginal and non-Aboriginal students over five cycles (1995 to 2011) in the case of TIMSS and cycles 2000–2012 in the case of PISA. In light of these results, Thomson (2006, p. 19) suggests that Australia needs to investigate ways to “implement curricula that enable classroom teachers to demonstrate in engaging and meaningful ways the application of science and maths to the phenomena that students encounter in their lives.”

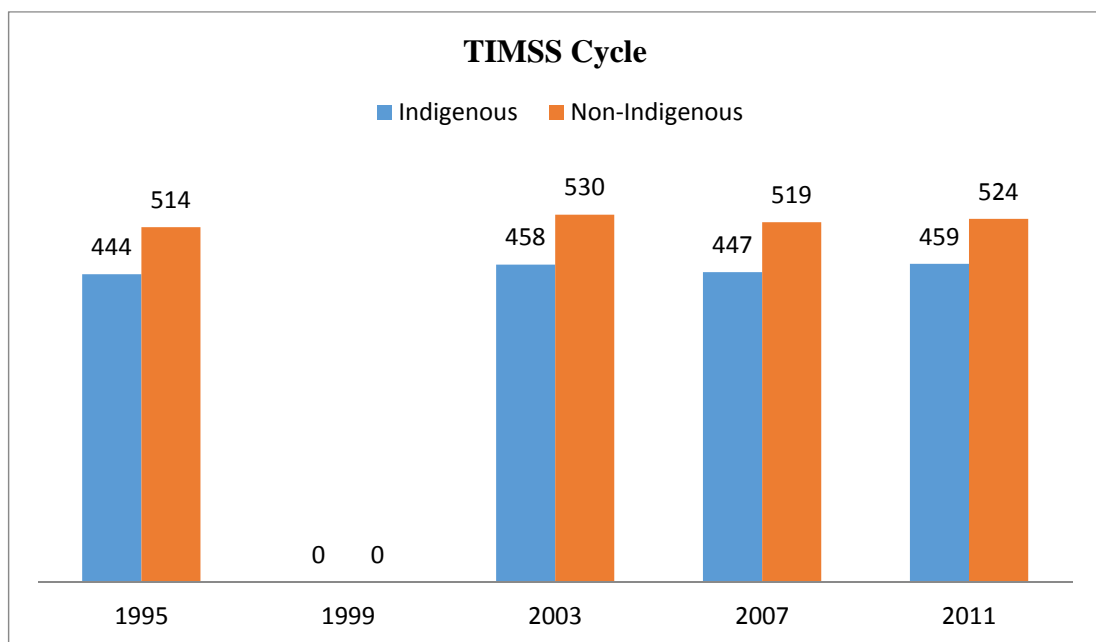


Figure 3.1: Comparison of TIMSS results for Aboriginal and non-Aboriginal students (1995, 1999, 2003, 2007 and 2011). (Adapted from Thomson, Hillman, Wernert, Schmid, Buckley & Munene, 2012, p. 56)

The National Year 6 Science Test

The National Year 6 Science Test is an Australian assessment of Year 6 Australian students’ achievement in science. It was established in July 2001 by the Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA) to test and report on the skills, knowledge and understanding of Year 6 Australian students in science. The National Year 6 Science Test is administered every year and the results for Aboriginal and non-Aboriginal students for the years 2003 to 2012 are reported in Table 3.2. Similar to PISA and TIMSS, the results for the four testing periods indicate that the gap in achievement for Aboriginal and non-Aboriginal

students has not reduced over this time, with Aboriginal students continuing to lag behind their non-Aboriginal counterparts.

Table 3.2: Comparison of National Year 6 Science Test scores for Aboriginal and non-Aboriginal students (2003, 2006, 2009 and 2012) in Australia

Year	Mean score	
	Aboriginal	Non-Aboriginal
2003	350	412
2006	311	402
2009	297	397
2012	303	399

Extracted from the National Assessment Program – 2012 Science Literacy Year 6 Report (Australian Curriculum, Assessment and Reporting Authority, 2013. p. 63).

Examining the results of PISA, TIMMS and the Year Six National Science Test is relevant to my research. They identified gaps in the science achievement of Aboriginal and non-Aboriginal students, helping me to find ways to understand why this is happening and how it can be addressed. The data provided from these tests also provides a backdrop for discussion with the Aboriginal Consultative Group, connecting me to my research participants and their science learning, and allowing me to reflect on how best to forecast, plan and implement the innovation.

Barriers to Science Achievement

Australia’s Aboriginal children are recorded as having “the worst Indigenous educational outcomes of any comparable Western settler society” (Gray & Beresford 2008, p. 204). These barriers are complex and diverse and are likely to impede their educational opportunities (de Plevitz, 2007; Fleming, 2005; Malin & Maidment, 2003; Mellor & Corrigan, 2004; Ministerial Council for Education Early Childhood Development and Youth Affairs, 2010; Storry, 2007; Urquhart, 2009; Zubrick et al., 2006). The barriers can occur within many aspects of a school, including: its buildings and physical arrangement; school organisation, cultures and policies; the relationship between and amongst children and adults; and approaches to teaching and learning. Barriers may be found, too, outside the boundaries of the school, within

families and communities, and within national and international events and policies (Booth & Ainscow, 2011).

The range of barriers have been well-documented and include:

- A lack of relevance of school curriculum to Aboriginal culture (Cajete, 1986; Fleming, 2005)
- A lack of understanding of Aboriginal culture and ways of learning (Aikenhead, 1996, 1997; Biddle & Cameron, 2012; Dockery, 2013; Kawagley, 1990; Ogawa, 1995 Patten & Ryan, 2001)
- Poor school attendance (Purdie & Buckley 2010)
- Inappropriate assessment frameworks (Klenowski, 2009)
- Poor teacher quality (Behrendt & McCausland, 2008)
- High teacher turnover (de Plevitz, 2007)
- Racism and prejudice towards Aboriginal students (de Plevitz, 2007)
- Low literacy and numeracy (Lamb, Walstab, Teese, Vickers, & Rumberger, 2004)
- Socioeconomic factors (Hunter, 2010; Purdie & Buckley, 2010; Reid, 2008)
- Health and wellbeing; low birth weight; speech difficulties; high risk of clinical emotional or behavioural difficulties; substance use; and adolescent pregnancy (Zubrick et al., 2006)
- Community perceptions that reflect a poor link between education and employment (Helme, 2010)
- Limited employment opportunities (Helme & Lamb, 2011); and
- Geographical isolation (Helme & Lamb, 2011).

In looking specifically at why Aboriginal students disengage with science, four main reasons have been cited: the persistence of assimilation practices; a lack of recognition of and support for Aboriginal pedagogy; ignoring Aboriginal students' cultural identity; and disregard of their languages, traditions, and histories. Each of these is discussed below.

Persistence of Assimilation Practices

The persistence of assimilation practices in science education is viewed as a barrier to Aboriginal students' science achievement, as teaching science from a purely Western cultural perspective does not affirm Aboriginal students' cultural knowledge, which can lead to alienation from science (Cajete, 1999; Chigeza & Whitehouse, 2014; Costa, 1995; Ogawa, 1995). According to Linkson (1999, p. 41), there is a cultural bias in science, in which the subject matter is inextricably linked with the progress of Western civilisation; therefore, teaching science to Aboriginal students can diminish or even demolish the faith they have in their Aboriginal cultural beliefs. This view is supported by Aikenhead and Jegede (1999) who argue that, when the culture of science is generally at odds with a student's life-world, science instruction will tend to disrupt the student's worldview by trying to force that student to abandon or marginalise his or her life-world concepts.

Examples of disparities between Western and Aboriginal science can be found from around the world. For example, Western science teaches that rain occurs through the process of evaporation and condensation, whereas the Ngunggubuyu people of south-east Arnhem land associate rain with the performance of a ritual rain dance (Linkson, 1999). In another example, science education generally teaches about the western view of four distinct seasons, whereas Aboriginal people have different ways of dividing the year up depending on where in Australia they live. These seasons are defined by changes in nature, including tides, plant blooming and fruiting cycles, insect abundance, and the breeding cycles and migrations of fishes, mammals, and birds (Davis, 1988). Similarly, in Africa, beliefs are still maintained that lightning is caused by witchcraft, whereas the Western scientific explanation is that it is caused by discharge of electricity between clouds (Bridges, Burbules & Griffiths, 2015).

Associated with assimilation practices is the lack of use of Aboriginal pedagogies in science classrooms, which has the potential to prevent students from learning science (Aikenhead & Huntley, 1999). Currently, the pedagogies used in Western science teaching are objective, quantitative, positivist and materialistic in nature, focusing on analytical and reductionist methods. This is in contrast to Aboriginal pedagogies and traditional knowledge, which are necessarily subjective, qualitative, intuitive,

holistic, spiritual, and make no distinctions between empirical and sacred (Roué & Nakashima, 2002). Further, Western science is more academic and based on the written word, in stark contrast to the practices of traditional knowledge, which is often passed on orally by the Elders from one generation to the next (Roué & Nakashima, 2002). Some Aboriginal students learn differently (Preston & Claypool, 2013), and therefore, tailored pedagogies work better at engaging them in education.

Embracing Aboriginal Students' Cultural Identity

Another barrier to science achievement is the lack of acknowledgement of Aboriginal students' cultural identity. Tripcony (2010, as cited in Perso, 2012, p. 7) states that "culture is the foundation upon which individual identity is built." Aboriginal cultural identity includes ancestry, country of origin, and perceptions of self as Aboriginal. It is not about genetics or skin colour, but about relationships and obligations with people and place (country) or kinship (Dudgeon, Milroy & Walker, 2014). Burney (1994) stresses that being Aboriginal and having an Aboriginal cultural identity is a spiritual feeling, an identity you know in your heart.

In the 1970s and 1980s, a group of pioneering scholars, including Manuel Ramirez and Alfredo Castaneda (Ramirez, Castaneda & Herold, 1974), Ronald Edmonds (Edmonds, 1986), and Wade Boykin (Boykin, 1986) constructed an alternative view to the prevailing cultural deficit paradigm that maintained that people from certain cultural groups lack the ability to achieve because of their cultural background (Gay, 2010). This alternative standpoint, known as the cultural mismatch paradigm, asserts that students of colour may experience failure in school because their cultural characteristics are incongruent or incompatible with those of mainstream students and the school system (Lessow-Hurley, 2000). According to Manning and Baruth (2009), teachers who match the culture of diverse students to the curriculum give their students a greater likelihood of academic success.

Ignoring Aboriginal students' cultural identity in education, and in particular in science, has been found to impede Aboriginal students' achievement (Appleyard, 2002, p. 31). Appleyard (2002) points out that the loss of identity associated with ignoring cultural identity can lead to a loss of self-esteem and respect, culminating in

educational failure. Cultural exclusion has been recorded as a factor in the high rates of attrition among Aboriginal students (Fleming, 2005).

Including Aboriginal Languages, Traditions, and Histories

The presence of Aboriginal languages, traditions and histories in science is not a daily occurrence. Science classrooms are often places in which Aboriginal children are implicitly and explicitly told that the knowledge of their people, their histories, and their ways of developing knowledge of the world are merely perceptions or are incorrect (Bang, Medin & Cajete, 2009, p. 8). This disregard of the languages, traditions and histories of Aboriginal students is viewed as a potential barrier to Aboriginal student achievement in science (Fleming, 2005).

The language of instruction in science classes can present a barrier to Aboriginal students because of the complex vocabulary of the science language (Harlow, 1993). Although many Aboriginal students may bring Aboriginal English into their science classes, this may not be sufficient to translate and understand the context (Tangen et al., 2010). Being taught in a language that they do not relate to, in addition to being confronted with a worldview that challenges their own, can be disempowering for Aboriginal students (Appanna, 2011).

The work of Atleo (2009) suggests that the disregard of Aboriginal traditional ways of learning has resulted in eroding the guiding educational practices of traditional cultures. When Western science does not affirm and include Aboriginal language, histories and traditions, this creates a barrier for Aboriginal students. As a result, students can feel alienated from science, as they do not see its relevance to them (Cajete, 1994).

Practical Barriers

In addition to the barriers outlined above, there are also practical barriers that impact on Aboriginal students' achievement in science. These practical barriers are wide-ranging, and a sample of them is provided below.

- Insufficient science resources in remote communities have been reported to impact on the learning of Aboriginal students, as people who live in rural and remote communities in Australia are more likely to be Aboriginal (Hackling, Byrne, Gower & Anderson, 2015).
- There is a lack of expenditure on remote Aboriginal communities by the government and a lack of equitable funding (Kronemann, 2007).
- There is a low level of teacher efficacy and expectation (Talbot-Smith, Abell, Appleton, & Hunuscin, 2013).
- There are low levels of student self-expectation (Day, 2007).
- A rigid science curriculum can be superfluous and detached from most students' understanding of the science they experience in their daily lives (Fensham, 1997; Goodrum, Hackling, & Rennie, 2001).

Reviewing the barriers that impact on Aboriginal students' engagement in science was an important precursor to the process of embedding Aboriginal perspectives in science in this study. Understanding the barriers and why they exist helped to establish effective practices in embedding Aboriginal perspectives.

Part Three: Embedding Aboriginal Perspectives: Culturally Responsive Curricula

The need to improve Aboriginal students' engagement has been widely acknowledged. Whilst there is no single solution that will engage Aboriginal students in science, there is mounting empirical evidence to suggest that the practice of embedding Aboriginal perspectives in science might provide a means of making inroads into this problem. In this section, my review begins by defining what embedding Aboriginal perspectives means. The review then goes on to provide a brief history of the culturally responsive movement and finishes by outlining both the challenges associated with embedding Aboriginal perspectives and the outcomes of embedding student perspectives.

The Culturally Responsive Curriculum Movement in Australia

In this section, I provide background information related to embedding Aboriginal perspectives into the curriculum, first internationally and then nationally. As discussed earlier, the history of embedding Aboriginal perspectives into the curriculum is located within the culturally responsive curriculum movement. This movement commenced in the early 1970s, in response to the increasing classroom diversity in the United States (Abrahams & Troike, 1972), and the acknowledgement that students' language and culture could be viewed as resources rather than as barriers to learning. Thus, the culturally responsive curriculum movement emerged as a promising strategy for improving the education and increasing the academic achievement of Native American and Alaskan native students (Beaulieu, Sparks, & Alonzo, 2005; Demmert, Grissmer, & Towner, 2006; Demmert, McCardle, Mele-McCarthy & Leos, 2006; Dick, Estell, & McCarty, 1994; Klump & McNeir, 2005).

Two countries that were foremost in developing approaches to curriculum and pedagogy to facilitate Aboriginal student engagement and to provide professional development for teachers in cultural literacy were the US and Canada. The introduction of the culturally responsive movement in these countries had a ripple effect in other countries with high populations of First Nations people. Australia is one of them. This section provides a brief history of the movement in Australia.

In the early 1980s, the National Aboriginal Education Committee responded to the culturally responsive movement by calling for schools to “develop an educational theory and pedagogy that takes into account Aboriginal epistemology” (National Aboriginal Education Committee, 1985, p. 4). The committee also stated that “only when this occurs will education for our people be a process that builds on Aboriginal and Torres Strait Islander cultures and identity” (National Aboriginal Education Committee, 1985, p. 4). The Aboriginal Education Policy Task Force recommended that a coordinated national education policy be formed, and in 1988, the National Aboriginal and Torres Strait Islander Education Policy (AEP) was instituted (National Aboriginal Education Committee, 1985). The AEP aimed to ensure “better educational results for Australia's Aboriginal people” with the following key elements (DEST, 2000, p. 8):

- Involving Aboriginal and Torres Strait Islander people in educational decision-making
- Equality of access to educational services
- Equity of educational participation
- Achieving equitable and appropriate education outcomes.

The policy changes made in 1988 and 1990 were further strengthened when the Report of the Royal Commission into Aboriginal Deaths in Custody was presented in 1991 (Royal Commission into Aboriginal Deaths in Custody, 1991). This report was commissioned to examine the causal, legal, social and cultural issues behind Aboriginal people dying in custody, and recommended that curricula should reflect Aboriginal history as well as Aboriginal viewpoints on social, cultural and historical matters.

A further step towards a culturally responsive curriculum in Australia was the acknowledgement by the Ministerial Council on Education, Early Childhood Development and Youth Affairs (MCEETYA, 2005) of Aboriginal languages in their National Statement for Languages Education in Australian Schools. This statement emphasised the need for education to focus on developing intercultural understanding as well as to integrate language, culture and learning to help learners to know and understand the world around them. This National Statement (MCEETYA, 2005, p. 7) identified that:

Australian Aboriginal and Torres Strait Islander languages have a unique place in Australia's heritage and in its cultural and educational life. For Aboriginal and Torres Strait Islander learners, they are fundamental to strengthening identity and self-esteem. For non-Aboriginal and Torres Strait Islander learners, they provide a focus for development of cultural understanding and reconciliation.

In 2009 the state, territory and Commonwealth Ministers of Education met with the Ministerial Council on Education, Early Childhood Development and Youth Affairs (MCEETYA, 2008) and endorsed a set of Educational Goals for Young Australians

(known as The Melbourne Declaration). Of importance to the culturally responsive movement was the elaboration of the following goals for schools:

- Build on local cultural knowledge and experience of Aboriginal students as a foundation for learning, and work in partnership with local communities on all aspects of the schooling process, including to promote high expectations for the learning outcomes of Aboriginal students.
- Students will appreciate Australia's social, cultural, linguistic and religious diversity, and have an understanding of Australia's system of government, history and culture.
- Students will understand and acknowledge the value of Aboriginal cultures and possess the knowledge, skills and understanding to contribute to, and benefit from, reconciliation between Aboriginal and non-Aboriginal Australians.

MCEETYA also developed the National Statement of Principles and Standards for More Culturally Inclusive Schooling (MCEETYA, 2000b) and this, together with the Early Years Learning Framework and National Quality Standards (DEEWR, 2010), required teachers to respect Aboriginal cultures in the classroom. The requirement for teachers to respect Aboriginal cultures in the classroom was also documented in The National Aboriginal and Torres Strait Islander Education Action Plan 2010–2014, which has a key priority to ensure that:

[E]ducation providers will deliver professional learning to teachers to ensure high levels of cultural and linguistic understanding and competencies to inform the best teaching strategies for Aboriginal and Torres Strait Islander students. Recognises the need for all Australian children to understand and acknowledge the value of Indigenous cultures and possess the knowledge, skills and understanding to contribute to, and benefit from, reconciliation between Indigenous and non-Indigenous Australians. (MCEECDYA, 2008, p. 8)

In 2004, a set of guidelines, known as Embedding Aboriginal and Torres Strait Islander Perspectives in schools P–12, School Guidelines for Administrators and Educators (Department of Education and Training, 2011), was introduced by the

Queensland Government for all schools and teachers. The guidelines were intended to help teachers to examine their role in embedding Aboriginal and Torres Strait Islander Perspectives and to better understand the role that the Aboriginal and Torres Strait Islander perspectives play in the curriculum for all students. The guide also provided information about how to include perspectives in teaching and the influence that these can have on the success for Aboriginal students (Indigenous Education Queensland, 2014).

A further step for the culturally responsive curriculum movement in Australia came about with the establishment of the Australian Curriculum Assessment and Reporting Authority (ACARA, an independent authority set up to introduce a national curriculum) in 2009 (ACARA, 2010). One of the goals of ACARA, which received directions from the Australian Government, was to ensure the inclusion of Aboriginal perspectives into the national curriculum ‘to ensure that all young Australians have the opportunity to learn about, acknowledge and respect the history and culture of Aboriginal people and Torres Strait Islanders’ (ACARA, 2010, p. 20). ACARA has subsequently engaged with experts across the state and territory curriculum, school authorities and representatives from the Indigenous Education Consultative Bodies (IECBs) through face-to-face national forums to seek advice about appropriate resources and protocols (see ACARA, 2010). To assist with this, an Aboriginal and Torres Strait Islander advisory panel has been established to guide the development of the Australia curriculum for English, science and history (ACARA, 2010).

In Western Australia, where the research reported in this thesis was carried out, the education department made a commitment to include Aboriginal perspectives in the curriculum. *Aboriginal Perspectives Across the Curriculum* (Department of Education WA, 2012) was established as a project by the Education Department of Western Australia to broaden and deepen students’ and teachers’ understanding of Aboriginal cultures and ways of being. The project is web based and provides a range of resources for teachers, designed to assist them to implement Aboriginal perspectives in their lessons.

The Deadly Ways to Learn Project, also an initiative of the Department of Education, WA (Cahill & Collard, 2003), is a two-way teaching strategy that incorporates Aboriginal pedagogies (including negotiation, collaborative group work, problem-solving, integration and hands-on activities) and reduced teaching control (which tends to dominate many Western pedagogies). Literacy targets for Aboriginal students who participated in the Western Australian Deadly Ways to Learn Project were exceeded by 50% through a program of teacher cross-cultural awareness training (Cahill & Collard, 2003).

In Australia, the movement to embed Aboriginal perspectives in science gained momentum in 2009, when the Australian Curriculum Assessment and Reporting Authority (ACARA) acknowledged and recognised Aboriginal scientific knowledge and included it as one of the three cross-curriculum priorities (ACARA, 2011). ACARA noted that science values Aboriginal and Torres Strait Island histories and cultures. It acknowledged that Aboriginal and Torres Strait Islander peoples have long-standing scientific knowledge and traditions. ACARA affirmed that in exploring scientific knowledge and decision-making about Earth processes, environments and resources, students need to develop an understanding that Aboriginal and Torres Strait Islander peoples have particular ways of knowing the world and continue to be innovative in providing significant contributions to development in science (ACARA, 2011).

Further acknowledgement of the importance of embedding Aboriginal perspectives in science was noted in two major reports: the Australian School Science Education National Action Plan 2008–2012 (Goodrum & Rennie, 2007) and *Re-imagining Science Education: Engaging Students in Science for Australia's future* (Tytler, 2007). Both reports indicated that national and international priorities in science have changed and there is growing consensus on indigenising the science curriculum.

Other initiatives to include and teach Aboriginal culture are documented by the Department of Education, Employment, and Workplace Relations (DEEWR 2008), which succinctly outlines the Australian National, State and Territory Policy and Curriculum for the Teaching of Indigenous Culture in Schools. A current

requirement from Education Departments in each of the states and territories of Australia is that teachers embed Aboriginal perspectives across all key learning areas (ACARA, 2011).

The Australian Government has also launched a number of initiatives to address student engagement in science in general, and Aboriginal students' engagement specifically. The Primary Connections Aboriginal Perspectives Framework, developed through the Australian Academy of Science (2010), aims to accelerate science and literacy learning outcomes for Aboriginal students and increase non-Aboriginal students' and teachers' awareness and understanding of Aboriginal perspectives (Bull, 2008). This resource provides examples of ways that teachers can embed Aboriginal and Torres Strait Islander perspectives relevant to particular aspects of science in the curriculum.

Another pertinent resource related to the embedding of Aboriginal perspectives in science is the Living Knowledge, Indigenous Knowledge in Science Education project. Developed by the Australian Research Council (ARC), the project aims to determine the most effective ways of incorporating Aboriginal knowledge within the NSW secondary school science curricula (The Living Knowledge Project, 2016).

To complement the Living Knowledge project, the Eight Aboriginal Ways of Learning website is a web-based resource that was developed by the New South Wales Department of Education and Communities initiative and based on Tyson Yunkaporta's Eight Ways of Learning (Yunkaporta, 2009). The website presents an Aboriginal framework that teachers can use to start the process of incorporating Aboriginal perspectives through "Aboriginal learning techniques ... [since] Aboriginal perspectives are not found in Aboriginal content, but Aboriginal processes" (Yunkaporta, 2009, p. 3).

Despite the development of resources, policies and other moves to encourage the embedding of Aboriginal perspectives into the general curriculum and in science, the process has been found to present challenges for teachers and curriculum developers, as discussed in the next section.

Challenges of Embedding Aboriginal Perspectives

Past research has indicated that there have been numerous challenges which continue to emerge as curriculum designers seek to embed Aboriginal perspectives and teachers implement practices. The most prominent of these challenges are described below.

First, in the Australian context, it has been suggested that the Australian National Curriculum fails to truly advance a deep understanding of the histories and cultures of Aboriginal Australia (Lowe & Yunkarporta, 2013). Lowe and Yunkarporta (2013, p. 12) state that “The current inclusion of Aboriginal and Torres Strait Islander content is weak, and often tokenistic and unresponsive to historical and contemporary realities.” In their study, they note that flawed documents have been distributed to school systems and teachers to develop curricula that address authentic Aboriginal and Torres Strait Islander content.

Second, the fear of tokenism in the process of embedding Aboriginal perspectives has been a challenge. For example, dot painting, making damper or adding pictures of didgeridoos or boomerangs to an assessment is clearly not embedding Aboriginal perspectives. Shipp (2013, p. 26) raises this issue and urges teachers to:

... get rid of the word tokenism from their vocabulary as at its worst, the word allows many thousands of teachers to continue to teach the Anglo-Australian content with which they are most comfortable and continue to exclude Aboriginal and Torres Strait Islander perspectives.

Third, some researchers have argued that when Aboriginal knowledge is embedded into the science curriculum, it becomes devalued, whereas it should stand on its own and be valued for its own merits (Cobern & Loving, 2004). This criticism needs to be considered; however, this study holds that in reality, embedding Aboriginal perspectives does increase the importance of Aboriginal knowledge and elevates its position in the curriculum, at least from absence to presence. Furthermore, for non-Aboriginal teachers who take up teaching positions in predominantly Aboriginal communities, embedding Aboriginal perspectives is a starting point. Embedding

perspectives is an initial step to reconciling Aboriginal and Western science knowledge, and non-Aboriginal teachers need to be wary of providing inaccurate representations of Aboriginal knowledge (Zurzolo, 2006). Further, there are many systemic barriers to Aboriginal knowledge standing on its own as a subject in schools, and unless changes are made at government level, the best teachers can do at the moment is to embed Aboriginal perspectives as a positive way to action change.

The fourth challenge is the cultural competence of non-Aboriginal teachers and the question of whether they are competent to teach Aboriginal perspectives (Clark, 2008; MacNaughton, 2001). In line with this, some studies have documented that teachers have difficulty in incorporating Aboriginal content (Blood, 2010; Cherubini, 2011; Deer, 2013; Kanu 2011; Snowball, 2014; Zurzolo, 2006) and some teachers hold negative views of Aboriginal knowledge (Baynes & Austin, 2012; Glasson et al., 2010; Phiri, 2008).

Lowe and Yunkarporta (2013) found that many teachers were not adequately provided with the content needed; they were ill-resourced and unsupported. These teachers did not have the tools to construct learning experiences that provided students with the depth and breadth of content needed to acquire a deep understanding of the histories and cultures of Aboriginal and Torres Strait Islander peoples. Harrison and Greenfield (2011, p. 65) note that “teachers often lament that they know little about Aboriginal people, while questioning how they can be expected to include Aboriginal perspectives in their programs.” Gower and Byrne (2012) consider that the cultural competence of teachers may be more valuable than content knowledge, as it provides the teacher with an informed position for understanding Aboriginal issues, culture and way of life. This is not to say that content knowledge is not important, but rather that the teachers’ approach and willingness to embed Aboriginal perspectives holds great value.

The fifth challenge is that teachers lack time to adequately include Aboriginal perspectives in their lessons (Baynes, 2016; BurrIDGE & Evans, 2012). It has been reported that teachers experience pressure to cover more content without more time given, which prevents quality teaching of the curriculum (Whittaker & Young,

2002). Embedding Aboriginal perspectives into the curriculum creates an additional task for teachers, and the time available often means that embedding Aboriginal perspectives is not done (Dinham, 2013).

Addressing teachers' lack of time to embed Aboriginal perspectives is an urgent matter of concern, as the growing number of Aboriginal children entering school has implications for schools and governments alike. In 2011, the percentage of Aboriginal people under the age of five years was double the percentage for the rest of the population. Enrolments by Aboriginal and Torres Strait Islander students between 2006 and 2016 increased from 40.1% to 59.8%. In 2016 there were 207,852 students enrolled in Australian schools identifying as Aboriginal and Torres Strait Islander – an increase of 3.6% from 2015 (ABS, 2016). These statistics should serve to convince teachers that they will be encountering more Aboriginal students in their classrooms, and accordingly, they will need to prepare both personally and professionally to support these students.

Further, the Australian Professional Standards for Teachers (AITSL, 2011c) specify what teachers should know and be able to do in order to teach Aboriginal and Torres Strait Islander students and to teach all students about Aboriginal and Torres Strait Islander languages, history and culture. Teachers need to meet requirements in the following focus areas:

Focus Area 1.4: Strategies for teaching Aboriginal and Torres Strait Islander Students

Focus Area 2.4: Understand and respect Aboriginal and Torres Strait Islander people to promote reconciliation between Indigenous and non-Indigenous Australians.

In their study 'Improving teaching in Aboriginal and Torres Strait Islander education: Australian Professional Standards for Teachers' Ma Rhea, Anderson & Atkinson (2012) reviewed the policy and practice context for teacher professional development and learning in Aboriginal and Torres Strait Islander Education. They also reviewed the workforce development and change management literature on system-wide

school reform, in order to develop an understanding of the system-wide dimensions of the change envisaged with the implementation of the Australian Professional Standards for Teachers (NPST). They specifically focused on teachers' professional development and learning of relevance to Focus Areas 1.4 and 2.4.

Their report found that:

- An extensive policy framework regarding the provision of education services to Aboriginal and Torres Strait Islander Australians exists. However there is lack of evidence that these developments are guided by a rights-based socioeconomic framework even though Australia is a signatory to the Declaration on the Rights of Indigenous Peoples.
- There has been no research conducted about workforce development as applied to the Australian education system with respect to Aboriginal and Torres Strait Islander Education.
- There is some empirical evidence predominantly drawn from other former British colonial nations, and a few from Australian studies, about the effectiveness of teacher professional development programs designed for improving teaching of Aboriginal and Torres Strait Islander students in mainstream education systems, but nothing on how teachers might be supported to champion reconciliation based on their improved understanding of Aboriginal and Torres Strait Islander cultures.

The findings, therefore, call for:

Focus Area 1.4: practical strategies for working with students, including developing culturally inclusive curriculum, improving student behaviour, language and literacy, using new resources and finding ways to enhance the student-teacher relationship.

Regarding Focus Area 2.4: understanding history; learning intercultural or cross-cultural skills involving the development or changing of teachers' personal attitudes, expectations and understandings of the 'other' culture; and creating inclusive, intercultural classrooms or schools. (Ma Rhea et al., 2012)

The sixth challenge facing the practice of embedding Aboriginal perspectives is the issue of reliance. Embedding Aboriginal perspectives in schools is heavily dependent on the individual and school perspective of Aboriginal curriculum content (Anderson & Atkinson, 2014). Each school and teacher is left to implement the process of embedding Aboriginal perspectives without uniform guidelines or policies. Past research by McConaghy (2000, p. 182) found that “many contemporary approaches to Indigenous education incorporate Indigenous values and cultural practices in superficial or exoticised ways.” Some examples include dot paintings or Aboriginal dances which, according to McConaghy (2000, p. 182), “usually serve to do little more than re-enforce cultural stereotypes” instead of meaningful learning of Aboriginal culture.

Although only six major challenges are discussed in this section, there are undoubtedly many more that exist. Of special note are the findings of MaRhea et al. (2012, p.6-14), who identify the following issues:

- Organisations’ policies and lack of a guiding vision statement that recognises Aboriginal and Torres Strait Islander rights and social justice.
- No evidence of structured policy or resourcing commitment across Australia with respect to teacher professional development in the Aboriginal and Torres Strait Islander domain as a workforce development issue.
- Lack of system in Aboriginal and Torres Strait Islander education as part of workforce development.
- Scant evaluation of formal professional development provisions.
- Formal teacher professional development is patchy, ad hoc and lacking in cohesiveness.
- Noticeable drop-off in demand for formal professional development for topics associated with an Aboriginal and Torres Strait Islander pedagogy focus, but not in Aboriginal and Torres Strait Islander cultural awareness and cultural competency programs.

Teachers have fear and resistance about these particular focus areas.

In my study, while I worked in collaboration with the science teacher as she attempted to meet the challenges that she was faced with, my practice was informed by these findings on the principles and challenges to the pedagogy and practice of embedding Aboriginal knowledge in science teaching,

Embedding Aboriginal Perspectives: Improving Student Outcomes

This section examines past research related to embedding Aboriginal perspectives in the curriculum and whether doing so improves student outcomes. Although this field is still growing, past studies indicate that embedding Aboriginal knowledge and perspectives has the potential to:

- Improve the academic performance of Aboriginal students;
- Improve the attendance and participation of Aboriginal students;
- Build better relationships between Aboriginal and non-Aboriginal students;
- Enhance the social identity of Aboriginal students;
- Increase interaction with the local community, parents and Elders;
- Improve the engagement of Aboriginal students.

Dunbar and Scrimgeour (2009, p. 2) claim that “culturally responsive teaching is positioned as fundamental to improving the academic outcomes for students commonly referred to as members of marginalised, diverse or minority groups worldwide.” A review of literature related to each of these outcomes is provided below.

Past studies carried out in other countries provide evidence to support that embedding Aboriginal perspectives in the curriculum leads to improved academic achievement for Aboriginal students (Holm & Holm, 1995; Lipka, 1990; Lipka & McCarty, 1994; Barnhardt & Kawagley, 2008; Klump & McNeir, 2005; Krakouer, 2015; Munns, O'Rourke, & Bodkin-Andrews, 2013; Watahomigie & McCarty, 1994, 1997; Watahomigie & Yamamoto, 1987). Research carried out within Australia by Hunter (1997), Partington (1998) and Malin (2002) support this growing body of international research, suggesting that embedding Aboriginal perspectives has a positive impact on the achievement of Aboriginal students.

Interestingly, a study by Brenner (1998), known as the Kamehameha Early Education Program (KEEP) for Native Hawaiian students, found that embedding Aboriginal perspectives led to higher reading and math achievement for students in the program than for students not in the program (Lipka, 2002; Tharp & Yamauchi, 1994). It must be noted, however, that when the techniques developed for KEEP were used in a different schooling context (with a different cultural group), similar results were not found (Demmert & Towner, 2003). This point is important, given that no research of a similar nature has been reported for the cultural group that my study focuses upon, therefore no direct comparison is possible.

Research has consistently found that when Aboriginal perspectives were embedded in the curriculum, the attendance and participation of Aboriginal students improved (see for example, Cahill & Collard, 2003; Purdie & Buckley, 2010; Rahman, 2010; Yunkaporta & McGinty, 2009). Studies have found that embedding Aboriginal perspectives leads to: improved behavioural engagement (Rahman, 2010; Yunkaporta & McGinty, 2009); reduced misbehaviour (Yunkaporta & McGinty, 2009); increased retention rates – or reduction in dropout rates (Kim, 2015; Klump & McNeir, 2005; Living Knowledge Project, 2016; Rahman, 2010); improved retention within the community (Friesen & Friesen, 2002); improved graduation rates (Snively & Williams, 2006); and improved enrolment rates at school (Klump & McNeir, 2005). Other studies have found that, where Aboriginal perspectives were embedded in science, there were improvements in students' enrolment in science programmes Berkowitz (2001) as well as their orientations toward science and science career choices (Van Eijck & Roth, 2009).

Involving Aboriginal perspectives in the curriculum has been found to strengthen student self-concept and cultural identity (Tuharsky, 2000). It has been documented that by embedding Aboriginal perspectives in the curriculum, students' social identity is acknowledged, and that this can turn learning into a more positive experience (De Beer & Whitlock, 2009). This acknowledgement of a students' social identity has been found, in turn, to strengthen students' participation in formal education (Dockery, 2013; Howard, Perry, & Butcher, 2006; Lowe, 2011). Given

that the social identity of Australia's Aboriginal students is a key government priority (Niezen, 2003), this finding was of particular relevance to my study.

Past research has found that embedding Aboriginal perspectives into the curriculum leads to a stronger connection between schools and teachers, and local Aboriginal communities, community leaders and members (Beveridge & McLeod, 2009; Pudussery, 2009; Pearce et al., 2005; Kitchen & Hodson, 2013). For example, findings from a study by Alkholy (2015) show that students taught with Aboriginal Elders as co-educators have significantly greater interest in science, technology, engineering and mathematics subjects than students not exposed to Elders' teachings.

Embedding Aboriginal Perspectives: Student Engagement

Because the study reported in this thesis focuses on the engagement of Aboriginal students in science lessons and whether this improved when Aboriginal perspectives were embedded into the curriculum, this section reviews literature relevant to student engagement. The section starts by defining student engagement and identifies the two aspects of engagement that were relevant to this study (emotional and behavioural engagement). The section goes on to review past research that has examined the impact of embedding Aboriginal perspectives on student engagement. In particular, this section focuses on research that has been carried out in Australia in science.

Defining Student Engagement

There are many definitions of student engagement, but a persistent theme across the definitions emphasises that student engagement is a multidimensional construct, dynamically interrelated, with numerous overlaps (Fredericks, Blumenfeld, & Paris, 2004, p. 61). Student engagement is defined by Trowler (2010, p. 3) as an "interaction between the time, effort and other relevant resources invested by both students and their institutions intended to optimise the student experience and enhance the learning outcomes and development of students and the performance, and reputation of the institution." For the purpose of this study, Fredericks, Blumenfeld and Paris's (2004) definition of student engagement is used, as this is most relevant to the research questions. They define engagement as having three

components: behavioural, emotional and cognitive. Behavioural engagement is evidenced by students' participation in social, academic and extracurricular activities. Emotional engagement is when students exhibit positive attitudes and reactions towards school, teachers, learning, and peers. Cognitive engagement occurs when students make a personal investment in learning in a focused, strategic, and self-regulating way. Of relevance to this study are the emotional and behavioural components of engagement, as these are the constructs that my study focuses on. Therefore, these two components are expanded upon below.

Emotional Engagement

Emotional engagement is defined by Fredricks, Blumenfeld and Paris (2004) as a student's interests, values and emotions, including his or her reactions to academic work (such as interest or boredom) and feelings about his or her school and teachers (such as liking or disliking). Student behaviour is shaped by emotions and plays an important role in students' academic achievement and adjustment (Garcia & Pekrun, 2010; Li & Lerner, 2011; Wang & Degol, 2014; Wang & Fredricks, 2014). Much past research has indicated that the emotions that a student has with respect to school and education are related to his or her motivation to learn (Efklides & Petkaki, 2005; Fredrickson, 2001)

Students who report positive emotions during academic activities learn more and experience deeper engagement (Järvenoja & Järvelä, 2005; Pekrun, Goetz, Titz, & Perry, 2002). Conversely, students who experience negative emotions while learning, such as boredom or anxiety, are likely to avoid tasks in order to minimise these unpleasant feelings (Goetz, Frenzel, Pekrun & Hall, 2006; Larson & Richards, 1991; Nett, Goetz, & Hall, 2011; Pekrun, Goetz, Titz & Perry, 2002). In their study of the relationship between students' emotions and their academic engagement, Reschly, Huebner, Appleton and Antaramian (2008) found that students' positive emotions (such as feeling happy or excited) during school were associated with deep engagement, while negative emotions (such as boredom or anxiety) were related to shallow or no engagement. Meyer and Turner (2006) suggest that emotional engagement forms the foundation for teacher-student relationships and the interactions necessary for the motivation to learn.

Behavioural Engagement

Behavioural engagement is defined by Davis, Shalter-Bruening and Andrzejewski (2008) as a student's effort, persistence, participation, and compliance with school structures. It typically refers to students who comply with behavioural norms such as attendance and involvement, and who do not display disruptive or negative behaviour (Fredricks, Blumenfeld, & Paris 2004). Skinner and Belmont (1993, p. 572) state that these students:

[S]how sustained behavioural involvement in learning activities accompanied by a positive emotional tone. They select tasks at the border of their competencies, initiate action when given the opportunity, and exert intense effort and concentration in the implementation of learning tasks; they show generally positive emotions during on-going action, including enthusiasm, optimism, curiosity, and interest.

It has been found that students who demonstrate challenging behaviours at school are at increased risk of academic failure, delinquency, dropping out, gang membership and adult incarceration (Dunlap, 2006). As Newmann (1986) points out, you know engagement when you see it, and you know it when it is missing.

Despite the growth of the culturally responsive curriculum and the embedding of Aboriginal perspectives into curricula, research related to the effectiveness of a culturally responsive curriculum on practices is relatively new and somewhat limited (Griffiths, 2011). This study extends past research by examining the impact of embedding Aboriginal perspectives in the year 9 physics curriculum on Aboriginal student engagement.

Impact of Embedding Aboriginal Perspectives on Student Engagement

This section reviews literature related to the embedding of Aboriginal perspectives specifically in science, and empirical studies that show its effectiveness in terms of student engagement. The availability of such evidence in the literature, however, is sparse, but the most significant ones available are examined here.

Three significant studies carried out in the US (González-Espada et al., 2015), the Caribbean (George, 2013) and Haiti (Hudicourt-Barnes, 2003) provide empirical data that documents that Aboriginal students were more positively engaged with the science curriculum when their cultural knowledge was validated. One of the teachers, involved in the Caribbean study by George (2013), reported:

I was amazed that my students in Form Four enter the classroom with so much back-ground/cultural knowledge.... Although students were hesitant to share their knowledge at the beginning of the interview, maybe because they were fearful that their contributions would have been laughed at, there came a point when I was basically bombarded with traditional knowledge and I found great difficulty to jot down all the information given. Students became loud and excited. (George, 2013, pp. 2123-2124)

Similarly, the US study by González-Espada et al. (2015) involving 57 Hispanic students in a low-resource, urban public school, found that contextualised activities in science improved the perception of the subject in many children, particularly boys, who were able to engage more effectively with their science learning.

In Canada, where there was a significant under-representation of Aboriginal students in high school science, it was found that, when Aboriginal perspectives were included in the science curriculum, there was an increase in the engagement of Aboriginal students in science (Aikenhead et al., 2014; BC Ministry of Education, 2005; Nunavut Department of Education, 2005; Kim, 2016; Friesen & Ezeife, 2013). Supporting this claim, researchers Sutherland and Henning (2009) in Canada carried out a literature analysis study and then an interactive action-research project with 50 cross-cultural science educators from schools and found a similar engagement of Aboriginal students in science, citing four main components for the success of such a program. Students experienced a personal, participatory, constructive, and holistic process towards gaining wisdom-in-action; students received cross-cultural pedagogy; there was social and ecological justice in science and more ecological literacy (Sutherland & Henning, 2009).

Dublin, Sigman, Anderson, Barnhardt and Topkok (2014) developed the traditional science fair into an ocean science fair that promoted the integration of Western science and Alaskan Native traditional knowledge in student projects focused on the ocean, aquatic environments, and climate change. The result of this approach was to engage Alaskan Native and rural students in science practice that was relevant to their cultures and communities (Dublin, Sigman, Anderson, Barnhardt, & Topkok, 2014);

O'Connor and Sharp (2013) examined whether public school programs incorporating place-based and experiential learning engaged students in science and related civic actions. They found that 90 per cent of the students graduated from university and more than 60 per cent of these in science fields; 70 per cent have worked in a variety of employment fields linked with science. In most cases, the students identified the place-based and experiential learning as influential in their selection of science courses and professional careers (O'Connor & Sharp, 2013).

International examples of increased engagement have also been reported at the Russian Mission School in Alaska, where Native knowledge is integrated with academic standards through embedded Aboriginal perspectives. It was found that the engagement of students in science and the relationships between students, teachers and Elders not only improved but was sustained over two decades (Klump & McNeir, 2005).

Research related to embedding Aboriginal perspectives in science carried out with Kickapoo Aboriginal students in Canada (Kim, 2015) found that student dropout rates fell from 69 per cent to 16 per cent over a year. In other research, graduation rates for Aboriginal students reached 100 per cent for two consecutive years (Snively & Williams, 2006). This research related to improved engagement has had a ripple effect at the tertiary level. Research in Nova Scotia, Canada, reports that, after embedding Aboriginal perspectives in the curriculum, Aboriginal student engagement in science soared (Berkowitz, 2001).

Similarly, in New Zealand, the mandatory development of the *Pangamu* (science) curriculum increased Maori involvement in science (as the mainstream science curriculum was failing to engage Maori students) (McKinley, 2005). The new science curriculum that includes Maori knowledge and beliefs related to science has enabled Māori students to engage with Euro-Western science learning and to negotiate “boundaries between their home culture and the culture of science” (Glynn, Cowie, Otrrel Cass, & Macfarlane, 2010, p. 126).

Munns, Martin and Craven (2006) found that culturally responsive teaching has the potential to improve Aboriginal student's self-concept and, by extension, their motivation and engagement with education. The authors note that Aboriginal students' engagement with education can be positively improved through the adoption of culturally responsive teaching methods (Munns, Martin and Craven, 2006).

In Australia, research related to embedding Aboriginal perspectives in science is limited. The studies that have been documented, however, do provide information of successes experienced when Aboriginal students learn science within their cultural milieu. These practices, as discussed below, were instrumental in providing contextual and background information for my study and supported my endeavour to implement a practice locally with the Aboriginal students at my research site.

Strong contributions made to the practice of embedding Aboriginal perspectives in Australia were initiated by Dr Michael Michie, a teacher, consultant and science writer on how to engage in teaching Aboriginal science (Michie, 1998, 1999, 2000; Michie, Anlezark & Uibo, 1998; Michie & Linkson, 1999, 2000). Michie has implemented a culturally responsive science curriculum in the Northern Territory, and his research suggests that this could be an important vehicle for social justice and reconciliation between Aboriginal and non-Aboriginal students. His findings suggest that, when Aboriginal perspectives are embedded into the science lessons, students are more positively engaged than previously (Michie, 1998, 1999, 2000). Michie's findings on how embedding Aboriginal perspectives in science can forge reconciliation in Australia are particularly significant to my study, as forging

reconciliation between Aboriginal and non-Aboriginal students has emerged as a theme in this study.

Cahill and Collard (2003) and Davison and Miller (1998) also found that embedding Aboriginal perspectives in the classroom improved Aboriginal and Torres Strait Islander students' engagement, participation and pathways into further education and work.

Similarly, a study by Yunkaporta and McGinty (2009) at the college level in New South Wales found that, when Aboriginal perspectives were introduced into the curriculum, the behavioural engagement of Aboriginal students improved. Qualitative data from teachers' and students' responses indicated that there were successful learning and behaviour outcomes when students worked in Aboriginal learning circles. Students in the study enjoyed their equal roles in the use of Aboriginal cultural knowledge through the interface method (Yunkaporta & McGinty, 2009). Furthermore, their results found that redirection of misbehaving students was only possible when aspects of content were connected to the land or Aboriginal community life (Yunkaporta & McGinty (2009).

In Western Australia, the Primary Connections Indigenous Perspective Framework was piloted in seven primary schools. This framework embedded Aboriginal perspectives in the science curriculum (Bull, 2008). The results of this study suggest that embedding Aboriginal perspectives in science contributed to: increased engagement with learning for all students; increased awareness and understanding of science and Aboriginal perspectives; connectedness; motivation and participation of Aboriginal students; increased teacher confidence and competence with linking science and literacy and Aboriginal perspectives; improved relationships and partnerships across the school and wider community; and the establishment of links between schools, parents and community (Bull, 2008).

Another empirical study that documents the success of embedding Aboriginal perspectives in science (using the Sharing Place, Learning Together program), was carried out in a remote community school in Western Arnhem Land (Godinho,

Woolley, Webb & Winkel, 2015). Findings suggest that as a result of embedding Aboriginal knowledge, student engagement increased. Further, the study found that the program built capacity in both basic Western and Aboriginal scientific knowledge and in the reproduction of Aboriginal ecological knowledge (Altman et al., 2011).

These findings suggest that embedding Aboriginal perspectives in science may help Aboriginal students develop positive cultural identities which could lead to improvements in access, participation and retention in science for Aboriginal students (Lee et al., 2012).

An Aboriginal science engagement program run by a Western Australian organisation known as Sci-tech (a not-for-profit organisation that provides programs to increase awareness, interest, capability and participation in science, technology, engineering and mathematics) takes hands-on science activities to schools in remote Aboriginal communities. This program recorded overwhelming success from connecting Aboriginal perspectives to Western science. According to Hackling, Byrne, Gower and Anderson (2015), a significant increase was recorded in student ratings of their enjoyment of science, curiosity about science phenomena, and their ratings of science as a favourite subject during the program. Furthermore, teachers engaged in the program reported that their students' focus and engagement increased, as well as their attendance and behaviour. The reasons cited for this increased engagement in science include: the pedagogical practices that were implemented such as relationship building; facilitation of effective hands-on activities; participation in classroom discourse; and connecting the science activities to the students' experiences and local content (Byrne et al., 2008).

Conclusion

The history of the colonisation of Aboriginal people in Australia and the accompanying social, political, and economic contexts in which science has been taught have resulted in many Aboriginal students presenting with an aversion to science. Science continues to be taught by non-Aboriginal people using non-Aboriginal methods and disregarding Aboriginal worldviews. The review presented

in this chapter of studies carried out internationally and within Australia suggests that embedding Aboriginal perspectives in the curriculum could be useful in helping to turn around Aboriginal student engagement in school (in general) and science (in particular). Of the few studies that have examined the impact of embedding Aboriginal perspectives in science in Australia, one examined its impact at the primary school level (Bull, 2008), and the remainder were carried out mostly in the Eastern States and Northern Territory. Therefore, my study builds on and extends these past studies by examining, on a small scale, the impact of embedding Aboriginal perspectives in the science curriculum for Nyoongar students located in an urban area of Perth, Western Australia. Further, the study reports the impact of embedding Aboriginal perspectives in the physics strand of the general science curriculum, which has not been explored in past research in Australia.

Chapter 4

Methodology and Methods

The research design and methodology for this study draws on recent innovation in the field, as well as exemplary research approaches and practices. The methods were selected with consideration of their relevance and appropriateness when undertaking research with Aboriginal people (Goulding, Steels & McGarty, 2016). The research procedures, including the selection of the research participants and the methods used to gather information, are aligned to ethical guidelines and core values that characterise research undertaken in Aboriginal communities. The resulting research design included methods situated in Aboriginal ontological, epistemological and ethical principles and involved creating an Aboriginal form of the Third Space (Bhabha, 1994).

The Aboriginal form of third space or cultural interface (Asante, Miike & Yin, 2013; Martin, 2009; McLaughlin, 2012; Miller & Roehrig, 2016; Nakata, 2002; Yunipingu, 2009) is described as a way of working with the Aboriginal research participants that allows both Aboriginal and Western worldviews to co-exist. This co-existence, with shared ontologies, was fostered by the inclusion of Western paradigms, including interpretivism (Creswell, 2009; Creswell & Clark, 2011), critical theory (Giroux, 1992; Hoy & McCarthy, 1994), and action research (Dickens & Watkins, 1999; Kemmis & McTaggart, 1988; Reedy & Goff, 2011; Stringer, 2007).

In consideration of the cultural interface, I sought to minimise the influence of colonial research practices and methods and focus on intellectual enrichment, social justice, social betterment and equity, as recommended by Ladson-Billings and Donnor (2005). This is significant in the current research climate as it fits into the emerging body of decolonising research, which argues that research with and of Aboriginal people should be respectful of and include Aboriginal ways of knowing and doing (Martin, 2003; Putt, 2013; Smith, 1999).

Through the inclusion of ontological values, coupled with a third space interface in which the co-existence of Aboriginal and Western worldviews was possible; three key elements of an appropriate methodology were identified: collaboration with the Aboriginal community; a high standard of trustworthiness and rigour; and the establishment of Aboriginal protocols and Aboriginal research methods. Further, the research methods included participatory action research (Dickens & Watkins, 1999; Kemmis and McTaggart, 1988; Khanlou & Peter, 2005; Lewin, 1946; Pine, 2009); the Aboriginal research method of yarning (Bessarab & Ng'andu, 2010; Franks et al., 2001; Fredericks et al., 2011; Geia, Hayes, & Usher, 2013; Goulding, Steels, McGarty, 2016) and observations (Creswell, 2009; Denscombe, 2003; Marshall & Rossman, 1989; Paton, 1980; Yin, 1994).

This chapter begins by describing my research design which included consultation with an Aboriginal Consultative Group, the use of participatory action research in the design of the materials to be used in the innovation, and the selection of the research participants. It then moves on to the research methods that were used in this study and the quality standards used to ensure the rigour of using these methods.

Research Design

My research design, or operational plan, included the structures that I put into place to organise how I investigated each of my research questions. I was ever cognisant of the fact that, historically, research has impacted the Aboriginal communities in a negative way, often resulting in harm and exploitation, and failing to address the needs of Aboriginal people (Henry, Dunbar, Arnott, Scrimgeour & Murakami-Gold, 2004; Houston, 1989). It was important, therefore, to formulate my research design to be harmonious with and correspond to the views held by my local Aboriginal cultural group, the Nyoongar People. To do this, I ensured that my research design adhered to the ways of the community, its tradition and its members (as recommended by Saini, 2012). As such, my research design acknowledged the lived experiences of Aboriginal people, including their histories, socio-cultural realities and health conditions (Dudgeon et al., 2010)

My research design provided space for the voices of the Aboriginal community and embodied a process that ensured that their voices were heard, understood and acted upon, as recommended by Smith (1999). To enable this, the research design was structured into three phases (depicted below in Figure 4.1). Each phase served to translate the knowledge of the local Aboriginal community, to reflect Aboriginal epistemologies, and to ensure that appropriate Aboriginal research methods were incorporated.

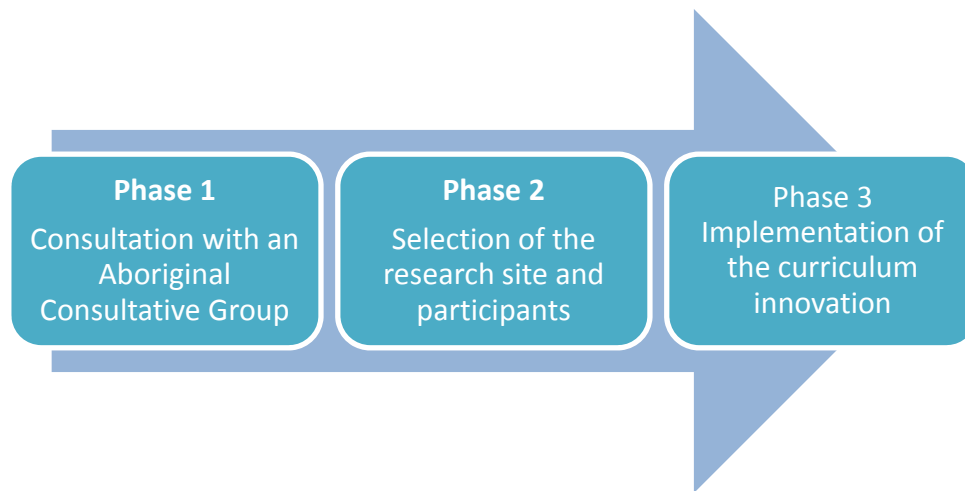


Figure 4.1: Three-phased research design

My three-phased design helped me to devise steps that I could follow and served as a plan for others who might want to replicate or adapt this study to their local context. It was recognised that generalisations should not be made in the social world (Williams, 2000); however, I anticipated that, if I created a map for teachers, then it would make their journey easier and give them some directions to follow when they attempt to embed Aboriginal perspectives into their own lessons. By mapping the steps or phases that I used, I hoped to contribute to the development of an idiographic body of knowledge (Guba & Lincoln, 1982) or the explication of an individual case which can be translated into other settings. In the following sections, the structure of each phase is described.

Phase 1: Consultation with an Aboriginal Consultative Group

The first phase of my study was possibly the most pivotal, as it involved identifying and consulting with the relevant Aboriginal Elders and community members who

would collaborate with me in this research. According to the Board of Studies NSW (2008), consultation is an ongoing process that benefits all participants equally in helping to ensure that Aboriginal voices are effectively incorporated into the curriculum. Further, consultation ensures that there is a respectful relationship, demonstrates a willingness to share, and enables researchers to become aware of community views, sensitivities and protocols (Dodson & Smith 2003; Nakata, 2007; Smith, 1999; Rigney, 2001).

My knowledge of Aboriginal protocols helped me during this phase. I had learnt, through working with Aboriginal students and the Aboriginal community, that engagement with Elders was the first step. Therefore, the first protocol was to approach the Aboriginal community for permission and guidance in my research process. There are many studies and guides about how to work with Aboriginal communities. I selected the *Engaging with Indigenous Australia: Exploring the conditions for effective relationships with Aboriginal and Torres Strait Islander communities* guide (Hunt, 2013). This section describes the key factors that underpinned my collaboration with the Aboriginal community members.

From outsider to insider: Establishing genuine relationships

Establishing relationships and building trust with Aboriginal people is a significant component to consider when working with Aboriginal people. Relationships, according to the literature, come before anything else, and outsiders who do not forge positive relationships with Aboriginal people often find their efforts frustrated (Department of Families, Housing, Community Services and Indigenous Affairs [FaHCSIA], 2012; Holmes 2011). I found myself in a fortunate position, having moved from outsider to insider by forming these meaningful relationships when, some 14 years ago, I started working with Aboriginal students. I was fortunate that one of my colleagues was a respected Aboriginal teacher who taught me that to achieve success with Aboriginal people the first step was to involve them in the process and to allow them to self-determine. This teacher became my mentor and someone to whom I could turn when I was unsure about the protocols that should be in place. This rapport with my mentor extended to the wider Aboriginal community, as I ventured out with her on school trips, camps, professional development

opportunities and home visits. My mentor maintained that recognising and upholding Aboriginal authority reconciles the historical injustices that Aboriginal people have experienced.

Inherent in the establishment of Aboriginal authority was the development of relationships, community involvement and engagement. From the outset of my study, I was guided to adopt a grassroots, bottom-up approach that would allow me to get to know the context of the community. To establish the required knowledge and rapport for this approach, I attended local barbeques, community forums and conferences, and visited various Aboriginal corporations and agencies.

I engaged in extensive accredited professional training to help me to better understand Aboriginal culture and the intergenerational effects of colonisation. During this process, I learned to acknowledge Country at all events and to use appropriate terminology. I became cognisant and considerate of unique Aboriginal ways of doing things, such as putting relationships before business. This was reflected in my interactions, such as allowing time to yarn before and after meetings. I worked hard to acknowledge and understand cultural obligations. I validated these in my professional settings by becoming more skilled with my interactions with different cultural groups and acknowledging individuality rather than treating everyone alike.

The Aboriginal community grew to respect me for putting them first and seeking out key Aboriginal members for advice, not only about the research but also about the protocols that I needed to follow. Over time, my interactions engendered a relationship of trust and I gradually moved from being an outsider to an insider. This move, in turn, facilitated easier access for research purposes, as I was able to identify key stakeholder and decision makers in my local Aboriginal community.

Identifying the Aboriginal Consultative Group

Community involvement was focused on the Nyoongar Community (the cultural group to which the study participants belong), drawing on respected Elders and community members. Identification of these leaders was based on the work of

Stiegelbauer (1996), who identified what constitutes an Elder, what Elders do, and how Elders can be used as teachers in culture-based organisations.

Identification of suitable Elders commenced with consultation with the local Aboriginal Corporation. As a non-Aboriginal researcher, I relied on the wisdom of the Elders to recommend other participants with the same characteristics and who belonged to the same cultural group. Using this method to locate Elders was valuable. There is also a comprehensive list of Elders who are willing to work in the community provided by the South West Aboriginal Land and Sea Council.

My task of identifying suitable Elders was facilitated by my well-established connection with an Aboriginal family and corporation in the local area, who had guided my work with Aboriginal students in the community. Nyoongar Elder, the late Shirley Thorne, an accepted Elder for the local area, gave her support for the research to be carried out. I was also fortunate to access the expertise and knowledge of an Aboriginal teacher who is a Nyoongar Elder, Kayleen Hayward, on a daily basis. As a work colleague and close friend for over 14 years, Kayleen guided me with respect to the protocols and Aboriginal teaching resources that would shape this research, thus increasing the cultural competence of my study.

I also approached Professor Colleen Hayward, a Nyoongar woman with family links throughout the south-west of WA, about my research topic. Colleen is the Head of Centre, Kurongkurl Katitjin, and Pro-Vice Chancellor (Equity and Indigenous) at Edith Cowan University, Perth, and is well-informed in Aboriginal cultural knowledge. She referred me to two of her staff members, Dr Noel Nannup and Mr Jason Burrow, both of whom generously provided me with information on how to link the prescribed science lessons to Aboriginal knowledge. Dr Noel Nannup is a Noongar Elder, storyteller, cultural ambassador, instructor and mentor. His ideas on how to embed Aboriginal perspectives into the curriculum can be found in his CDs: "The Carers of Everything," "When the Sea Level Rose," and "The Coming of the Colours," all of which were used as relevant reference materials in the curriculum innovation science lessons. Jason Burrow, also a Nyoongar man with widespread family ties throughout the South-West of Western Australia, provided me with

Aboriginal scientific knowledge that could be linked to Western science. His background in environmental science, heritage, cultural tourism, land management and land care was extremely useful in designing the curriculum innovation lessons.

As part of the curriculum innovation lessons, I was able to engage the support of two Aboriginal guest presenters who taught Aboriginal perspectives alongside the science teacher, namely, Derek Nannup and Thomas Dimer. These presenters partnered with the science teacher to teach Western science concepts from an Aboriginal perspective. Other members of the consultative group included Sam Garlett, Buffy Punch, Monica Eades and Garth Taylor.

Establishing how many members should be a part of the group was not problematic, as there is no ideal figure. Cresswell (2003) suggests six to eight people, and Sarantokos (1998) suggests between five and twelve. A group of 10 members agreed to form the Aboriginal Consultative Group, which comprised five males and five females. The members of the group held various roles in the community as well as secular jobs in education. The Aboriginal Consultative Group was coded as ACG, and each participant labelled from one to 10. Coding participant comments in terms of gender was not practised so as to avoid bias. Numbers were assigned to members, ranging from member one to 10, for confidentiality and anonymity.

In summary, the Consultative Group provided teaching resources and guidance on how to promote cultural competency through Aboriginal student engagement in science and suggested ways to facilitate the integration of Aboriginal Knowledge Systems into the teaching of science that is locally relevant and specific.

Working with the Aboriginal Consultative Group (ACG)

I worked with the Aboriginal Consultative Group to establish the research protocols and as part of participatory action research process in which the members of the group contributed to developing and designing the curriculum innovation.

Establishing the protocols

I worked with the Aboriginal Consultative Group to establish research protocols for the research design and methods of my study. The Aboriginal Consultative Group also helped me to develop Aboriginal teaching resources that would connect with the science syllabus. Working with the Aboriginal Consultative Group involved face-to-face contact, as recommended by Donovan and Spark (1997). I used this communication method to develop ongoing relationships with the Aboriginal Consultative Group and also used other forms of communication such as emails and telephone conversations. Face-to-face communication was easily accessible for those members with whom I worked.

Meetings with the Aboriginal Consultative Group were organised at times that suited the members and at various stages of the research. Meetings were arranged in consultation with group members, using university sites, school sites and informal outdoor meeting areas, as meetings through informal gatherings can help to engage Aboriginal and Torres Strait Islander people (Borg & Paul, 2004; Sims, 2011). The meetings ranged from two to three hours, depending on the members and how much they wanted to yarn.

I upheld the protocols of intellectual property by allowing the research participants to share their stories in a culturally safe manner. I encouraged a relaxed and informal structure and engaged in active listening at all times. Being attentive to detail and listening closely to stories not only encouraged members but prompted them to share more of their history and insights that could be included into the science lessons.

Participatory Action Research

In my work with the Aboriginal Consultative Group, I situated my research within the body of action research which is seen by Kemmis and McTaggart (1988, p. 5) as a form of collective, self-reflective inquiry. Action research is undertaken to improve the social rationality and justice of the researcher's own social or educational practices. Founded by Lewin (1946), action research was developed to bridge the gap between practice and theory (Dickens & Watkins, 1999) and to bring together appropriate theories for real world problem solving. Focusing on *change* and the

investigation of *change*, Lewin's paradigm of inquiry suited the main purpose of my study, to find a possible solution to the engagement of Aboriginal students in Science. This involved consulting with the Aboriginal community and implementing a curriculum innovation strategy recommended by the Aboriginal Consultative Group.

Whereas action research is a way of gaining a better understanding of a context by trying to improve aspects of it, participatory action research adopts a maximising and developmental approach to the building of action research capacity (Chevalier & Buckles, 2013; Crane, 2013). Given that the goal of participatory action research is to generate the involvement of research participants who are affected by a particular situation and to develop more robust and well-founded understandings, this approach was considered to be appropriate for working with the Aboriginal Consultative Group.

In keeping with the principles of action research, as advocated by Kemmis and McTaggart (2000, p. 595), my work with the Aboriginal Consultative Group encompassed a spiral of self-reflective cycles of: planning a change; acting and observing the process and consequences of the change; reflecting on these processes and consequences and then replanning; acting and observing; reflecting, and so on. This process facilitated immersion and, as such, had the potential to contribute "towards immediate improvements in people's lives, as well as providing a theoretical base for more wide-ranging social change" (Reedy, 2011, p. 1061). This process provides a "systematic approach to investigation that enables people to find effective solutions to problems they confront in their everyday lives" (Stringer 2007, p. 1). Given that action research is about "changing or improving a social situation and involving those most affected in the process of doing this" (Alston & Bowles 1998, p. 164), this approach was considered to be an ethical approach to conducting research in an Aboriginal context.

Participatory action research allowed me to consult with Aboriginal teachers, Elders and community members to gain their views and perceptions on the research topic and to include their voices in this research. Aboriginal community members and

experts were included in the development of the curriculum material for the curriculum innovation lessons, in the spirit of supporting them to re-establish their worldviews and knowledge (Gonzales et al. 2007, p. 79). Including the role of Aboriginal Elders in research is documented in studies, with Sherwood (2010) emphasising that their inclusion can help Aboriginal and non-Aboriginal research to be respectful and to generate an ethical dialogue with another worldview.

A distinctive feature of participatory action research is the participation of those affected by the issue, and the potential for them to be involved in making things better (Crane & O'Regan, 2010). This approach facilitated my consultation with Aboriginal people and helped to overcome the distrust of Aboriginal people towards outside researchers by engaging the participants in the research process at all stages. Taking the research question to an Aboriginal Consultative Group as I did in my research provided a space for Aboriginal people to contribute to thinking about an issue that concerns their community.

Phase 2: Selection of the Research Site and Participants

An important aspect of my research was the choice of a research site and the participants, which took into consideration the need to maintain a strong connection between my research aim and research design (Kvale & Brinkmann, 2009). The key considerations in the process were gaining access, obtaining the desired group of students and relevant Aboriginal consultees, and collecting relevant data. In selecting the research site, I took into consideration the school at which the research took place, the science classes and the participants, which included the students and the teacher.

Selection of the School

Initially, I approached the principal of a local middle school in suburban Perth, Western Australia to ascertain willingness to be involved in the study. The school had an enrolment of approximately 200 students of which 30 per cent were Aboriginal students. The principal of the school was keen to have her school and students involved in this curriculum innovation. The school was well situated to be part of the study as it has an Aboriginal Community Agreement which stipulates that

Aboriginal culture is unique and important to the Aboriginal people and the identity of the institution. One of the main goals of the school is to make education and training more meaningful for Aboriginal students.

Selection of Classes

All of the classes at the school were co-educational, as is typical in Western Australian government sector schools. There were only three science classes in Year 9, and all three classes were involved in the study. As the Aboriginal students were not grouped into one class, to allow all of them to participate meant including all three classes. Year 9 science was chosen because, in Western Australia, this is the second year of secondary school, and all students have to study science as one of their compulsory core subjects. During Year 10, students elect whether to continue with science or not; therefore, the opportunity to impact on the students' choices might be increased through this research.

Selection of Participants

Three main groups participated in this study: the Aboriginal Consultative Group (described earlier), the Year 9 science teacher, and Year 9 Aboriginal students. The latter are described below.

Selection of the Teacher

A science teacher was self-selected. As she was the only science teacher of the Year 9 cohort, I asked her if she would be interested in participating in my study. She consented to be involved in this study and gave permission for her science lessons to be observed. She was also keen to be involved in developing science-based lessons that would include Aboriginal perspectives. The teacher had no prior knowledge or experience of embedding Aboriginal perspectives into her science lessons. She had been teaching for 10 years in Western Australia.

Selection of Students

The clear criterion in this study was to focus on a particular characteristic of a group. With Aboriginality being central to the study, criterion sampling was the preferred

method. As there are no prescriptive rules about how many participants needed to be involved in research (Morse, 2000; Patton, 2005) determining the group size, ultimately, was dependent on the number of Aboriginal students enrolled at the school. Purposeful or criterion sampling (Ezzy, 2002) was used to provide a richness of data, a means that typically relies on small numbers (Miles & Huberman, 1994; Patton, 2005). I was comfortable with the use of purposeful sampling as it was “one that provides a clear criterion or rationale for the selection of participants or places to observe, or events that relates to the research questions” (Ezzy, 2002, p. 74).

Given these criteria, a group of 25 Aboriginal students spread across the three Year 9 science classes was selected for this study (5 in one class, 8 in another and 12 in the third class). These students ranged in age from 14 to 15 years. All of the students lived in the local community. Each class also included non-Aboriginal students present who came from a range of backgrounds including Australia, New Zealand, Asia, India and England. All of the students were included in the science lessons, but only the Aboriginal students were directly observed.

Phase 3: Implementation of the curriculum innovation

After gaining all approvals, including the support from the Aboriginal Consultative Group, the study was considered to be endorsed and ready to be launched at the research site. There were three stages involved in the implementation of the study that are depicted in Figure 4.2. I discuss these stages in detail to highlight the research process.

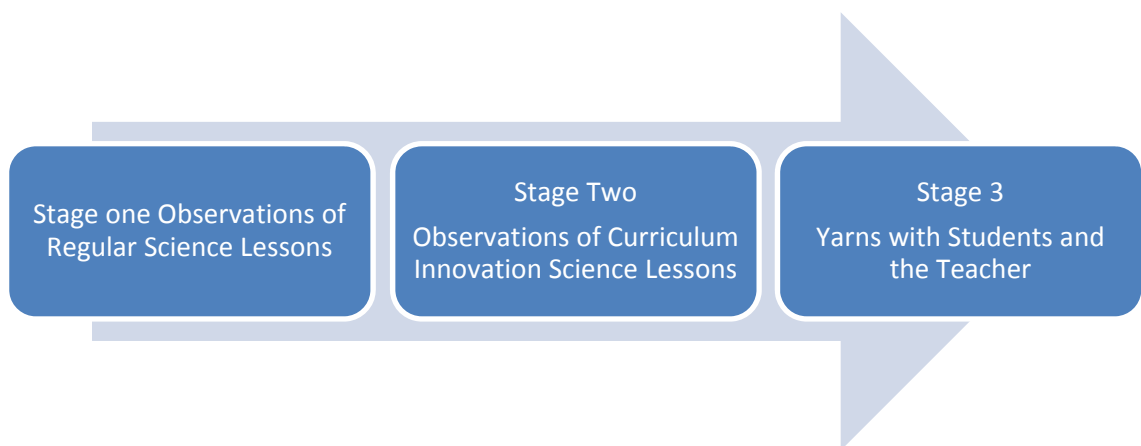


Figure 4.2: Stages of the implementation

Stage One and Two: Observations

Stage 1 and 2 involved me observing students as they studied science in the regular science classes (stage 1) and during the curriculum innovation lessons (stage 2). Stage one science lessons were entirely prepared by the teacher in accordance with her prescribed science syllabus. The stage two curriculum innovation lessons were prepared by the teacher in collaboration with the Aboriginal guest presenters to embed Aboriginal perspectives into the science topics prescribed for the term. They drew on information provided by the Aboriginal Consultative Group; the Department of Education curriculum document entitled *Aboriginal Perspectives across the Curriculum*; and other available and relevant learning resources to complement the science unit topics. Aboriginal pedagogies were integrated to complement the practice of embedding Aboriginal perspectives, which included yarning circles, storytelling, visual texts and hands-on learning.

Stage 3: Yarns with Students and the Teacher

The observations of both the regular and curriculum innovation science classes provided much data which I could discuss with the students and the teacher during the yarning sessions. The yarning sessions were the main component of stage three. Yarning, detailed in the research methods section (below), is an Aboriginal research tool that supports and facilitates Aboriginal ways of working (Bessarab & Ng'andu 2010; Martin, 2008; Moreton-Robinson, 2000; Smith, 1999; Nakata, 1997). Yarning is conducive to an Aboriginal way of doing things; its strength is in the cultural security that it creates for Aboriginal people participating in research (Bessarab & Ng'andu, 2010, p. 2).

During the yarning stage, I sat with students and the teacher, and we conversed about their experiences and perspectives on the regular and curriculum innovation science lessons. The yarning process is elaborated on in the research methods section below.

Research Methods

In this section, I present the research methods that I used as a non-Aboriginal researcher engaging with an Aboriginal community and Aboriginal research participants. I detail the reasons for the selection of my methods and the context in which they were used. My first consideration when selecting the research methods was to acknowledge and respect the protocols and ethics that have been standardised in the Aboriginal research community. I then positioned these guidelines into my personal context and that of my research participants. For this, I drew on the theoretical work of Aboriginal academics and researchers on Aboriginal research methodologies (Absolon & Willett, 2004; Kovach, 2005; Moreton-Robinson & Walter, 2009; Smith, 1999; Rigney, 2001; Thomas, 2005). Two key principles advocated by Aboriginal researcher Cora Weber-Pillwax (2004, p. 80) formed the pillars of my methodology: first, that the researcher is accountable for the effects of the research project on the lives of the participants; and, second, that the purpose of research should be to benefit the community and the people of the community. Bearing these two principles in mind, the research methods used in this study was a qualitative approach using action research, yarning and observation as tools.

Classroom Observations

Observations are "the systematic description of events, behaviours, and artefacts in the social setting chosen for study" (Marshall & Rossman, 1989, p. 79). Observations for evaluation purposes are endorsed by Paton (1980) for five reasons. First, observations allow direct personal contact that can help to understand the context. Second, observations enable the use of an inductive approach. Third, observations made by an outsider can provide a means of experiencing things that may routinely escape students and staff. Fourth, it is possible that the researcher can gather more information via observation than interview, as students may not divulge some details. Finally, observations allow for movement beyond the perceptions of others. In my study, observations were an important means of gathering, first-hand, evidence of what was happening in the classroom (Creswell, 2009; Denscombe, 2003).

During my observations of the research participants, I actively studied the engagement of Aboriginal students in the two different settings: the regular science classroom involving the mainstream science curriculum and innovative curriculum lessons. The science teacher involved in this study taught three year 9 classes per week. These classes were all timetabled to receive three one-hour science lessons a week (the teacher taught the same content in each of these classes). For both general and curriculum innovation lessons, one-hour classroom observations were carried out over the course of one 10-week term in all three of the classes. Hence, over the course of the school term, I observed each class for five hours, providing a total of fifteen one-hour observations. Observations were carried out in term 2 of the academic year (15 hours) for the general science lessons and in term 3, of the same academic year (15 hours), for the curriculum innovation lessons.

In both settings, I was a participant observer, in which my participation was moderate. Moderate participation allowed me to maintain a balance between my roles as an insider (though being an active part of the group) and an outsider (which allowed me to record the observations as they occurred) (DeWalt, DeWalt, & Wayland, 1998). My role as an insider allowed me the opportunity to form connections with the research participants which would assist in the yarning sessions (Yin, 1994). This role included helping individual students if the teacher was busy, clarifying information for students who were struggling, and informal interactions with the research participants (which were key to establishing rapport). In my role as an outsider, I positioned myself to the side of the room so that all students could be observed through targeted scans to records student behaviour.

The next two sections describe the identification of behaviours that were indicative of engagement how the observations were recorded.

Behaviours Indicative of Engagement and Disaffected

The core focus of my study was on student engagement. Student engagement was viewed as the intensity and emotional quality of the students' involvement in initiating and carrying out learning activities (Skinner & Belmont, 1993). According to Skinner and Belmont (1993, p. 572):

[Students] who are engaged show sustained behavioural involvement in learning activities accompanied by a positive emotional tone. They select tasks at the border of their competencies, initiate action when given the opportunity, and exert intense effort and concentration in the implementation of learning tasks; they show generally positive emotions during ongoing action, including enthusiasm, optimism, curiosity, and interest. The opposite of engagement is disaffection. Disaffected [students] are passive, do not try hard, and give up easily in the face of challenges... [they can] be bored, depressed, anxious, or even angry about their presence in the classroom; they can be withdrawn from learning opportunities or even rebellious towards teachers and classmates (p. 572).

My observations were centred on behaviours indicative of behavioural and emotional engagement. Behavioural engagement, which draws on the idea of participation, includes involvement in academic or social activities. Behavioural engagement, considered crucial for achieving positive academic outcomes and preventing dropping out (Li & Lerner, 2013; Reeve & Lee, W, 2014; Virtanen, Lerkkanen, Poikkeus & Kuorelahti, 2015), focuses on positive (and negative) reactions to teachers, classmates, academics, and school.

In identifying behaviours that were indicative of engagement (or disaffection), it was acknowledged that teaching and learning is highly inter and intra-personal and that, behind each behaviour, there is a reason for the behaviour. Therefore, in identifying what behaviour constitutes engagement, I sought an understanding of both the student and the event (e.g., what was the student involved in when a particular behaviour occurred). This was particularly important given that my intent was to examine whether a change in curriculum impacted on the engagement of Aboriginal students.

It is important to note that enjoyment and confidence are emotions or states of mind and, as such, cannot be observed. In deciphering what research participants experiences constituted enjoyment, four concepts, identified by Goetz, Hall, Frenzel and Pekrun (2006) and Hartley (2006), were used:

- *Flow*: students are absorbed and experience the activity as an end in itself;
- *Cessation of anxiety*: students overcome, without fear, a situation that formerly would have made them anxious or overwhelmed;
- *Security of belonging*: students enjoy working and being a part of a group, connecting with other students and engaging in task related conversations;
- *Positive Social relations*: students relate to other students based on warmth, empathy, respect, positive regard and interest.

In addition to the work of Goetz, Nathan, Hall, Frenzel and Pekrun (2006) and Hartley (2006), the identification of engaged and disaffected behaviours in my study drew on the work of Lane and Harris' (2015) and Christenson, Reschly and Wylie (2012), both of whom identified patterns of behaviour that were indicative of engagement and disaffection. Based on these theoretical grounds, I considered three broad indicators of engagement and disaffection (see Table 4.1): *Consistent Focus/Paying Attention; On Task/ Work Avoidance Behaviours and Verbal participation*. Table 4.1 provides, for each of these broad indicators, a list of student behaviours and actions that can be considered indicators. These indicators reflect the idea that actions are the natural unit of analysis for conceptualising transactions between people and their social and physical contexts (Connell & Wellborn, 1991; Deci & Ryan, 1985; Skinner & Wellborn, 1994).

Whilst it is acknowledged that there is some overlap between the three broad indicators, it was with these indicators of engaged and disaffected behaviours in mind, that I observed students during the lessons. During each lesson, I paid attention to what they were doing, what emotions they were displaying, what learning activity they were involved in, or failing to be involved in, and their social interactions. I did this over two school terms as explained above.

Table 4.1: Indicators of Engaged and Disaffected Behaviours

Consistent Focus/Inattentiveness	
Engagement	Disaffection
Students' body language indicates listening to the teacher, e.g.: <ul style="list-style-type: none"> • leaning forward, • position of arms and head towards the speaker. 	Students' facial expressions are unresponsive to the teacher's cues.
Students are focused on the learning activity with minimum disruptions, e.g., Instructions result in appropriate actions such as turning to a page of the text.	Students' eye contact is random and not related to learning activities.
Students are reading material related to the lesson. When a question is posed, the students flip through reading material to locate information/answer.	Students do not turn pages of their learning materials in response to instructions to do so.
Eye contact is focused on and following the material presented (during activities experiments or in worksheets/textbooks).	Students are involved in activities not related to the lesson, e.g., playing with phone, listening to music, doodling, playing with objects or off-task chatting to other students
On Task/ Work Avoidance Behaviours	
Engagement	Disaffection
Students working on given tasks by answering the questions/carrying out experiments/activities.	Students are not performing tasks related to the experiments/activities of the lesson.
Students following instructions and requests to participate in activities	Students do not follow instructions, including <ul style="list-style-type: none"> • moving around the room unnecessarily, • verbally refusing to participate, • challenging the teacher.
Students display attempts and active involvement in the given tasks.	Students look at other materials such as their mobile phones or other objects.
Students follow tasks assigned on the computer and log on to appropriate sites to gather information. Students' screen content matches the teaching content.	Students using a laptop inappropriately – e.g. surfing the web, playing games, checking emails.
Students ask relevant questions and ask for clarification.	Behaviours which distract from the learning process, e.g., wondering around the room, throwing objects.
Students take notes on in-class material, the timing of which relates to the teacher's presentation or statements. Students read with pen in hand, taking notes of highlighting.	Students display work avoidance behaviours, e.g.: <ul style="list-style-type: none"> • head on desk, • head thrown back • sounds such as groans or sighing.
Verbal participation	
Engagement	Disaffection
Students share thoughtful ideas and answers in response to teacher's questions and prompts.	Students jeer at the other students. Participating in side conversations that are not related to the task.
Students ask questions that are relevant or appropriate to learning.	Students are silent and non-communicative and do not offer responses to any questions. Students do not pose questions of their own.
Student engage in a purposeful way with peers; it involves sharing opinions and reflecting on problems.	When asked for a response, students put their heads down, have a blank expression or shake their heads.
Students seek or call out for help.	Student discussion does not relate to the class material.
Student discussion relates to the teaching /class materials.	Students ask questions that are unrelated to the lesson or topic.
Students' verbal and non-verbal behaviour indicates he or she is listening or explaining the class content expressed through hand gestures, pointing to notes, drawing or making points on what is being taught, asking the teacher questions that are related to the lesson or topic.	Students' verbal and non-verbal behaviour indicates frustration, anger, contempt, annoyance expressed through resistant or aggressive speech or body language.

Recording the observations

All of the classroom observations were conducted and recorded by me. Throughout the observations, during both the regular and curriculum innovation lessons, indicators of student engagement were recorded using anecdotal recordings and field notes (Cornelius, 2013; Floyd, 2011), and an ABC chart (Sugai et.al, 2000; Pratt & Dubie, 2008).

Anecdotal Recordings and Field Notes

Anecdotal notes and field notes were used to record information about student behaviours (Brown, 2012; Floyd 2011). The anecdotal records provided a written record of the students' behaviours (Floyd, 2011; Brown, 2012) in cases where I participated in the lesson. These records were written as soon after the event as possible so as not to forget what I had observed. These records were included in my research journal and included the following information: 1) date, time, and place of observation; 2) Specific facts, numbers, details of what happened; 3) personal responses to the records; and 4) specific words, phrases, summaries of conversations and insider language.

When acting as an outsider (as described above) I was seated to the side of the classroom so that I could concentrate on taking detailed field notes. In these situations, I was able to observe the phenomena (student engagement) in each of the settings (regular and curriculum innovation lessons) (as recommended by (Tomal, 2010). Field notes were recorded in a field book throughout these observations and involved recording as much information about what was taking place as possible.

ABC Charts

In addition to anecdotal records and field notes, significant episodes of behaviour that were observed in both the regular and curriculum innovation lessons were recorded using an ABC chart (Hadaway & Brue 2016). The ABC chart involved a three-column form that allowed me to record information related to events actions or circumstances that occurred with respect to what happened before the behaviour (Antecedent), the behaviour, act or action (Behaviour) and the action or responses

that followed the behaviour (Consequences). Using the ABC chart allowed me to record information not only about the act or action that the research participant exhibited but also contextual factors that included the antecedent information (what came before) and the consequent information (what came after). The ABC Chart allowed me to record descriptive information about both the student's behaviour and the environment in a systematic and organised way. An example of the ABC form with sample recordings from the observations can be found in Appendix H.

The ABC checklist provided information that could be analysed to examine the level of engagement of students during the mainstream and curriculum innovation science lessons. These notes also provided talking points during the yarning sessions where the research participants were asked to comment about why they had exhibited certain behaviours.

Yarning as a Research Method

Using the yarn as a research method was central to this study. The yarn was used with the teacher, students and members of Aboriginal research group. When Aboriginal researcher Bessarab first attempted to use yarning as a tool in her research, she was opposed by academics who disputed that it was a legitimate research method (Bessarab & Ng'andu, 2001). Since this time, yarning has been recognised as a means of centering Aboriginal knowledge systems and permitting partnerships with Aboriginal communities (Dean, 2010). As a research tool, yarning focuses on the Aboriginal ways of working and knowledge sharing (Geia, Hayes, & Usher, 2013; Goulding, Steels, McGarty, 2016; Martin, 2008; Moreton-Robinson, 2000; Walker, Fredericks, Mills & Anderson, 2014). Rigney (2001, p. 110) suggests that yarning might be a “step toward assisting Indigenous theorists and practitioners to determine what might be an appropriate response to delegitimise racist oppression in research and shift to a more empowering and self-determining outcome.” This section explains what yarning is and how it is used as an Aboriginal research method for data collection in this study.

Yarning is described as a prolonged, relaxed conversation. This conversational practice has been a long-held custom, originating from when traditional Aboriginal

people sat around the fire and shared stories. Based on the oral tradition of storytelling, the yarn has been developed into a culturally appropriate research tool (Bessarab & Ng'andu, 2010; Fredericks et al., 2011; Towney, 2005). In past research, the yarn has been used for similar purposes as interviews are used for (Martin, 2008; Moreton-Robinson, 2000; Nakata, 1997; 1998; Smith, 1999). The difference, however, lies in how yarning sets about investigating a question; it becomes both a process and an exchange, which incorporates the essential features of respect, protocol and engagement with the individuals' relationships with each other. In this way, yarning establishes relationality and accountability (Martin, 2008). Further, yarning engenders honesty and openness and empowers Aboriginal people to talk freely about their experiences, thoughts and ideas. In this way, it "enables the researcher to explore the topic in more depth, which results in information emerging that more formal research processes may not facilitate" (Bessarab & Ng'andu, 2010, p. 47). Using yarning as part of a methodological approach of participatory action research has been found to be successful by past action researchers working within a variety of Aboriginal contexts (Fredericks et al., 2011; Lucero et al., 2016).

In using yarning as a research method, I used the theoretical foundation of yarning developed by Bessarab and Ng'andu (2010) to ensure that, whilst implementing yarning in a culturally friendly and respectful way, I was still able to answer the research questions.

Typically, yarning occurs in a circle, which is symbolic of the Aboriginal non-linear way of doing things. Some communities and schools create a physical structure for this.

Wheaton (2000) suggests that this way of way of learning has become an Aboriginal pedagogy and involves a complex cycle of learning composed of multiple processes that occur continuously. Historically, Elders taught through stories, drawing lessons from narratives to engage youngsters in introspection and analysis (Wheaton, 2000). In research, the yarning circle produces genuine outcomes, with no single person's contribution being better than another's. Each contribution is valued equally and

respected by the others. In this way, everyone is included, and their sense of belonging and confidence is heightened.

There are four main types of yarning identified by Bessarab & Ng'andu, (2010): the social yarn; research, work or topic yarn; collaborative yarn; and the therapeutic yarn. This study incorporated all four types to engage students, the teacher and members of the Aboriginal Consultative Group, and to help to generate ideas for the curriculum innovation.

The Social Yarn

The social yarn, as used in my research, refers to the conversations which took place before dialogue related to the research topic. The social yarn is known as the relationship building stage (Bessarab & Ng'andu, 2010), and it was during this stage that trust was developed as we got to know each other. This “getting to know you” stage was important as it helped the Aboriginal participants to overcome their reluctance to engage with a non-Aboriginal researcher.

The social yarn helped me to promote positive interactions with the research participants and allowed me to establish a bridge between my world and theirs, with the assurance that the research would be culturally secure. Building trust, understanding and mutual respect with the research participants was seen as one of the fundamental first steps, and only when this was established did the research yarning begin.

Research Yarn

The research yarning was easier once relationships had been established. Having laid the basis for a relationship that was accountable to Aboriginal people, the process of digging deep into the research questions became easier. The research yarn allowed me to purposefully explore the research questions through in-depth discussions that yielded thick descriptions (Bessarab & Ng'andu, 2010). The research yarn as a method allowed me to honour the authority of the traditional owners of the land and the foundations of their knowledge systems, thus making them partners in the study rather than individual contributors (Dean, 2010). One of the strengths of using

yarning as a research method was that it allowed me to localise the knowledge to a specific Aboriginal group within the local area. Importantly, using yarns, as suggested by Dean (2010), ensured that experience, knowledge and relationships were engendered, making my research more meaningful for the Aboriginal participants and provided a practical means of disseminating my results.

The Collaborative Yarn

The collaborative yarn, as the name implies, is a two-way, common or shared communication. This style of dialogue was used with the Aboriginal Consultative Group to explore ideas and to share knowledge of the research findings, which led to new discoveries and understandings (Bessarab & Ng'andu, 2010). The Aboriginal teaching material was gathered during the collaborative yarning phase, where different views were shared and ideas developed as a concerted effort. It has been found that collaborative conversations or yarns have a transformative influence (Hollingsworth, 1994).

Therapeutic Yarn

In the course of yarning with research participants, the therapeutic element of the yarn emerged, particularly when research participants disclosed information that was traumatic or intensely personal and emotional (Bessarab & Ng'andu, 2010). When this occurred I adopted the role of listener and sought to “empower and support the participant to re-think their understanding of their experience in new and different ways” as recommended by Bessarab and Ng'andu (2010, p. 41).

Analysing the data

Analysis of the data, collected during observations and yarning sessions, was carried out sequentially. The section begins by describing the analysis used to answer the first research question, including the use of impressionistic tales and frequency tallies. The section then goes on to describe how thematic analysis was used to answer the second research question.

Frequency counts

Frequency counts or tallies were used to quantify the behaviours that were observed during the classroom observations. The data, recorded as anecdotal records and field notes, were used to determine how often the engaged and disaffected behaviours occurred during the regular science lessons and the curriculum innovation lessons.

Analysing the data to provide tallies involved examining the frequency of the targeted behaviours or specific events in the observation data (Reis & Gable, 2000). Using the behaviours indicative of engagement and disaffection, outlined in Table 4.1, I was able to tally the frequency with which these were observed. The number of times that a behaviour occurred over the course of the 15 one-hour lessons were then counted up and divided by 15 – to provide an average number of times that the behaviour occurred for a regular and curriculum innovation lesson. This method allowed me to examine the wide range of behaviours of the research participants and to provide an indication of the patterns of behaviour with respect to how frequently they occurred.

Impressionistic Tales

Impressionistic tales were used as a means of describing the observations and providing the reader with an insider's view of the classroom. How research is presented can be as important as what is presented and requires due consideration (Van Maanen, 1988). In my study, the use of impressionistic tales drew on the work of Van Maanen (1988, p. 102) who describes them as presenting the “doing of the fieldwork rather than the doer or the done [and are] a representational means of cracking open the culture and the fieldworker's way of knowing it so that both can be jointly examined . . . [by keeping] both subject and object in constant view”. Impressionistic tales can be likened to impressionistic paintings (an analogy made Van Maanen) and, as such, are intended to evoke a reaction from the reader. As such, impressionistic tales provided me with a means of describing the existing situation (involving observation data) using the five senses. Impressionistic tales have been used successfully in education settings in which the focus (see for example, Aldridge, Fraser & Huang, 1999; Geelan, 2004), in which the culture of the classroom is an important focus.

The standards involved for judging an impressionistic tale are somewhat different to other forms of inquiry, as explained by Van Maanen (1988, pp. 105-106):

Literary standards are of more important than scientific ones ... in telling a tale, narrative rationality is of more concern than an argumentative kind. The audience cannot be concerned with the story's correctness, since they were not there and cannot know if it is correct. The standards are largely those of interest (does it attract?), coherence (does it hang together?), and fidelity (does it seem true?). Finally, since the standards are not disciplinary but literary ones, the main obligation of the impressionist is to keep the audience alert and interested. Unusual phrasings, fresh allusions, rich language, cognitive and emotional stimulation, puns and quick jolts to the imagination are all characteristics of a good tale.

Two impressionistic tales (one about a regular science lesson and another about a lesson in which Aboriginal perspectives were used) were written to represent the classrooms. The tales involved extracting themes that were familiar over a number of observations. So, although the lessons were not related to any one lesson observation, the tale can be considered representative of a number of lessons. Through the impressionistic tales, my intention was to render the qualities of the classroom into language that would help the reader to perceive those qualities more deeply.

Importantly, the impressionistic tales were followed by an interpretative commentary (Geelan, 1997). These commentaries were used to place the impressionistic tale in context and to provide the reader with information related to other observations and yarns with the participants held over the same period. These commentaries and the impressionistic tales were used to provide a culturally sensitive basis upon which I could explain the differences and similarities of regular science lessons and those that included Aboriginal perspectives.

Thematic analysis

The second research question asked: What are the possible reasons for the increased engagement of Aboriginal students in science lessons that include Aboriginal perspectives? Although analysis at this stage was used to answer this research question, information also helped to inform research question 1.

Thematic analysis of data collected during the yarning sessions was used. Throughout the analysis, the use of bracketing (Ashworth, 1999; Charmaz, 2006) allowed me to suspend my judgements and to focus on the analysis of the participants' experiences. Bracketing involves holding in abeyance the researcher's own "repertoires of knowledge, beliefs, values and experiences in order to accurately describe participants' life experiences" (Chan, Fung and Chien, 2013, p. 2). In this study, bracketing was used as a method of validation to empower the voices of the participants by coming up with "reasonable conclusions and generalisations based on a preponderance of the data" (Taylor & Bogdan, 1984, p. 139).

Drawing on the work of Gale, Cameron, Rashid, and Redwood (2013). I utilised the six steps recommended to analyse the themes:

Step 1: Familiarisation

The data gathered from the observations during the two terms of science lessons and the yarns were organised into folders based on the type of data, time of collection of data and classes from which the data originated. My notes included all my observational comments, the dates, times and timetables and ABC forms. I listened to all of the audio recordings and transcribed them verbatim, considering the nonverbal expressions as I went along and noted the number of times specific issues were mentioned.

All of the comments and descriptions were typed into a word processing program. I read, and re read through all my notes and familiarised myself with the data to allow immersion in the raw data to commence. Once the yarns were transcribed, further familiarisation and immersion into the data was carried out which involved reading

and rereading the text. The next step comprised the process of grouping ideas and a brainstorm of initial key themes using a coding system.

During this stage I often went back to the research question, to remind myself of the objective.

Step 2: Coding

After preparing and organising the data, I began the process of locating and organising ideas and concepts. The main emphasis during this stage was to focus the analysis on the research questions to locate information, ideas and concepts that would lead me to answer them. The process of coding (Gale, Cameron, Rashid, & Redwood, 2013) involves reading and re-reading the data to identify patterns. I began this step off by making links between data that was the same to help me to bring the different data together into temporary categories that related to the same content (as recommended by Lincoln and Guba, 1985, p. 347). At this stage, I also created short words and phrases (codes) to describe the meaning and context of whole sentence or paragraphs. The codes also facilitated the numerical quantities that were added as tallies in the frequency counts which were later interpreted. The codes helped to quantify the qualitative data and gave meaning to the raw data. This facilitated the emergence of similar topics which developed into overarching themes. Further quotes made by the research participants that represented one of the highlighted themes was assigned a colour that represented an individual theme. If more themes emerged a new colour was assigned to them. The initial transcripts were thus coded to ensure agreement and consistency about codes to be used in subsequent transcripts.

Step 3: Developing the Analytical Framework

This stage involved the development of an analytical framework to identify the most significantly and/or frequently used codes and re-examining the data for any new codes. I also reduced data that was extraneous to ensure that only data that was significant was retained. A constant comparative method was used to look for similarities and then differences between the codes which involved taking one piece of data and comparing it with all others that may be similar or different. This process

facilitated the conceptualisations of the possible relationships between various pieces of data.

Step 4: Applying the Analytical Framework

Once my analytical framework was developed, as outlined in step 3, I focussed on applying this framework to draw reasonable conclusions and interpret what my findings meant. The application of this framework involved both logical and intuitive thinking, about what the research participants were saying; making judgments about meaning, about the relevance and importance of issues and about implicit connections between ideas. It was during this stage the research questions were fully addressed.

Step 5: Charting:

Charting, as the fourth step, involved summarising the specific pieces of data that were indexed in the previous stage to be now arranged or charted into themes. This meant taking the data from its original textual context and placed in charts that consisted of the headings and subheadings into themes. I generated a spread sheet to create a matrix and the data was charted into this matrix. I was careful during this stage to create a balance between reducing the data but at the same time worked at retaining the original meanings and ‘feel’ of the research participants’ words as authentically as possible. This was facilitated by using actual quotes from the research participants

Step 6: Interpretation:

The final step, interpretation, involved the analysis of the key characteristics as laid out in the charts that were carried out in step 5. Characteristics of and differences between the data were identified and connections were made between categories to explore relationships and/or causality. From these connections, themes were generated to explain possible reasons for the emergence of any phenomena that emerged during the study.

Using the framework approach in my study was a valuable tool for the analysis of my data. It provided an effective route map for my research journey and enabled a case and theme-based approach to my data analysis; adding to the rigour of my research process and enhancing the validity of the findings.

The Standards Used

It has been noted that “without rigour, research is worthless, becomes fiction, and loses its utility” (Morse, Barrett, Mayan, Olson & Spiers, 2002, p. 2). The quality of this study has been evaluated in terms of how it complies with the epistemological principles established by the Aboriginal research community, and the effectiveness of using the Western paradigms of interpretism and critical theory. To ensure high standards, I used the benchmarks recommended by Lincoln and Guba (1985), which have been widely used to ensure rigour in qualitative research. To ensure an accurate account of what I examined, I applied the four criteria Lincoln and Guba (1985) recommend: *credibility* (the study’s truth value); *transferability* (the applicability of a study); *dependability* (the consistency of the study); and *confirmability* (the neutrality of the study). Further to this I also used Bracketing (Chan, Fung & Chien, 2013).

As a non-Aboriginal researcher, I have sought to ensure that my study is *credible* to both Aboriginal and non-Aboriginal readers. Since people do not hold a single reality (Smith & Ragan, 2005), to make my study credible, I have been deliberate in my attempts to uphold Aboriginal research protocols. By establishing an Aboriginal Consultative Group and getting permission from the Elders in my community, I cemented a spirit of trust at grass roots level. I involved Aboriginal people during all stages of my research by partnering with them in establishing research aims, the research design and methodology, and curriculum material for the curriculum innovation lesson. Both Lincoln and Guba (1985) and Yin (1994, 2011), emphasise that for a researcher to maintain confidence in his or her work, concerted efforts must be made to adopt well-established research methods and correct operational measures for the concepts being studied. I was cognisant of this, and included Aboriginal research methods and methodology, which I examined extensively, and ensured that relevant research paradigms were used to build a relationship of trust,

respect and reciprocity. This acted as a foundation for my study and promoted the credibility of my research. As a non-Aboriginal person, I did not have the authority to speak on behalf of Aboriginal people. Partnering with Aboriginal people and sharing their knowledge, while building on my experience in Aboriginal education, have strengthened the worth and credibility of this research.

Regarding my background, qualifications and experience, Patton (2005) affirms that these add to the credibility of the researcher, as the researcher is the major instrument of data collection and analysis. Having worked in Aboriginal education for the past 14 years and gained many qualifications in this field, I was considered to be skilled both in theory and practice. Having served on many Aboriginal educational committees and presented at numerous national and international Aboriginal education conferences added strength to my credibility as a researcher. Furthermore, my personal positioning in this research as a subject of racial discrimination and colonisation helped me to shape my research from a decolonising perspective and to continue my personal journey out of a state of disadvantage and inequality. At all times, I made my position known to my research participants and presented my personal, biographical material as a valuable means of establishing credibility in my study (as recommended by Maykut & Morehouse, 1994).

By providing a thick description of the phenomenon under scrutiny, as recommended by Lincoln and Guba (1985), I have further contextualised my study and strengthened its credibility. In doing so, I have woven real life narratives into the research as well as actual yarns with research participants, providing insights into how Aboriginal people perceived the situations under investigation.

As recommended by Silverman (2001), I have related my findings to previous studies that have implemented Aboriginal perspectives in the science curriculum, both nationally and internationally, thus increasing the relevance and credibility of my research. This framework is supported by the data obtained from the research participants, which includes member checking and peer-debriefing, as explained below.

Member checking was used as a means of quality control in this study (Byrne, 2001; Coffey & Atkinson, 1996; Doyle, 2007; Lincoln & Guba, 1985). At all stages, I provided opportunities for the research participants to go over what they had shared in the yarning circles, for example, students were reminded of points they had made in earlier conversations. This not only gave them an opportunity to validate what they had said but also allowed them to make more comments if they wished.

Yarning thus played a role in the triangulation of the research data (Chilisa, 2012) as data yielded from stories and experiences gained through yarning enabled me to triangulate the Aboriginal values, beliefs and community histories with other sources of knowledge. This not only enhanced credibility but provided therapeutic benefits, as recommended by Drury, Francis and Chapman (2007). I also shared these yarns and other data with a non-Aboriginal teacher as part of a peer debriefing process (Lincoln & Guba, 1985), to limit any biases that I may have held.

Linked to the criterion of credibility is that of *transferability* of research. Transferability is achieved when the results of qualitative research can be generalised from one context or setting to another (Trochim, 2006). The findings of this study can be transferred beyond the bounds of this research and can be utilised by other schools and implemented by the Education Department as part of curriculum change. As such, its transferability will strengthen the credibility of the study.

To further satisfy the criterion of transferability, I have incorporated rich descriptions (Geertz, 1973) of the setting, research sites, and Aboriginal culture that have shaped the analysis, to allow the reader to make judgements about transferability. The detailed descriptions of my methods and context, supported by the practical components of research, have increased the transferability of the study. Further, the use of purposeful sampling to highlight a specific concern (in this case, the engagement of Aboriginal students) further highlights the transferability into other research that explores issues pertaining to Aboriginal people.

The dependability of my study is measured in terms of the extent to which my research findings can be replicated with similar subjects in a similar context

(Merriam, 1998). As advised by Lincoln and Guba (1985), I have ensured that the processes within my study are reported in detail, allowing replication. I have included information about how the curriculum innovation was conceived and how the lesson plans and resources were prepared and delivered. I have introduced a step-by-step design for teachers or researchers to either adopt or adapt with their particular community groups. Providing a tested method of implementing a curriculum innovation demonstrates that this project can be relied upon to work in a similar setting with Aboriginal students. The overlapping of both Aboriginal and Western research methods has increased the dependability of the study, validating the operational detail of gathering data in a more comprehensive manner (Saini, 2012).

Confirmability ensures that the research findings are well supported by the data and that the findings can be confirmed by others (Lincoln & Guba, 1989). At all stages of the research I have ensured that the data I collected emerged from the research participants without any personal pressure. As my study was qualitative and involved the subjective voice, I endeavoured to remove bias by acknowledging my own beliefs and assumptions (Lincoln & Guba, 1989). Even though I have shared my personal story and background, I have remained objective and have prioritised the views of the research participants, ensuring that the findings were based on what they had experienced. These findings were further corroborated by the Aboriginal Consultative Group.

I have also made known why I preferred and promoted the use of Aboriginal research methods and methodology as demonstrated by the literature (Absolon & Willett, 2004; Bishop, 1998; Kovach 2005; 2010; Moreton-Robinson & Kovach Walter 2009; Smith, 1999; Rigney, 2001; Thomas, 2005). I have provided detailed methodological explanations and examples to demonstrate the confirmability of my study methods and the believability of its data. I have maintained an audit trail and outlined clearly the steps taken and the decisions made (Saini, 2012).

Ethical Considerations

Studies involving interaction with a human group inexorably raises ethical issues. As a researcher, it was my legal responsibility to ensure the protection and safety of the participants in my research from any potential physical, psychological, spiritual, emotional or cultural harm. A large proportion of the research participants engaged in this study were students and as such the rights of Children to participate and voice their views, is noted and established in Article 12 of the 1989 UN Convention on the Rights of the Child (UNICEF, 2005), it allows children to express their voice in research. Furthermore, Groundwater-Smith, Dockett, and Bottrell (2014) note that the perspectives of children play an important role in social research. The value of consulting with students regarding their learning and educational experiences, and integrating such perspectives into teaching practices (Bishop et al., 2003; Cook-Sather, 2009; Lodge, 2005) has been recorded to “promote awareness of the dynamic interplay between perspectives, between ideas and practices, and between educational possibilities and actualities” (Cook-Sather, 2010, p. 559)

In terms of this research focusing wholly on Aboriginal students the guidelines established by the National Health & Medical Research Council (NHMRC) and the Western Australian Aboriginal Health Information & Ethics Committee (WAAHIEC) were strictly adhered to which incorporates the six core principles of Reciprocity, Responsibility, Respect, Survival and Protection, Equality, Spirit and Integrity as explained in detail in Chapter 1. The following ethical protocols were incorporated into this study, these being: informed consent; permission; privacy and confidentiality; and consideration.

Informed Consent

A clear, simple yet detailed information sheet, outlining the purpose and scope of the research study was provided to the principal, teacher, parents/guardians and students. The language used in the information sheet was at a reading level accessible to all participants. The information sheet included what was expected of the participants, a clear explanation of the purposes of the research and the procedures to be followed; a description of the risks and benefits that would be reasonably expected; an offer to answer any inquiries concerning the procedure and details of how privacy and

confidentiality and anonymity would be assured. The information sheet and consent forms were on Curtin University of Technology letterhead contained the researcher's contact information, the researcher's supervisor's contact information and the Human Research Ethics Committee contact information.

Students also received a verbal presentation outlining the research prior to data collection. All participants were informed that their participation was voluntary and they could withdraw at any stage of the research without prejudice or negative consequences. Further participants were provided with opportunities to ask questions both at the start and during the research and ongoing feedback was offered.

Permission

Prior to the commencement of this study written permission to conduct research at a Department of Education school was sought from the relevant section (see Appendix F) and Curtin's Human Research Ethics Committee (see Appendix G) the school principal, teacher, parents and students. After receiving consent from the Department of education, informed consent (written permission without coercion) was sought from the principal, followed by consent from parents and students. Copies of the information letters to the students, parents, principal and teacher can be found in Appendix A, Appendix B, Appendix C and Appendix D respectively.

Privacy and Confidentiality

Maintaining the privacy of all research participants was of high priority with participants being assured about the confidentiality of data. Participant identities have been protected and photographs that have been incorporated are ones where participants have provided signed permission. Student comments have been numbered instead of named ensuring anonymity.

The research participants are aware that the information provided is being used for a doctoral thesis and subsequent research publications. The participants received information about the storage of data, which is held on a password protected computer for a period of seven years. Access to this data is only available to the

researcher and supervisor. Further, interview data will be erased and raw survey data stored in a locked cabinet.

Consideration

I was highly considerate and aware that Aboriginal people are the custodians of knowledge and culture hence I always asked research participants if they were comfortable in sharing their yarns with me. Further, I took into consideration Aboriginal ways of knowing, being and doing as explained in Chapter 2 and 4. I was also considerate of the teacher's time and commitment to the study and ensured that there was minimal disruption to her teaching program. I did this by scheduling yarning sessions during, recess and lunch breaks and also during times when students had electives.

Conclusion

As I navigated the landscape of Aboriginal research methods and methodologies and looked into ways to compliment them into the western academy of research, I was confident that my research design and methodology created a culturally appropriate framework that supported the revitalisation and preservation of Aboriginal ways of doing research. Adopting this decolonising approach assisted in the development of protocols that worked within an Aboriginal cultural context. Utilising yarning as an Aboriginal research method in partnership with western methods of participatory action research which included observations, field notes, frequency counts and impressionistic tales allowed for a co-design and enabled an inclusive approach to enrich the current global changes advocated when carrying out research with Aboriginal people.

Chapter 5

Results:

Observations of Student Engagement

In this chapter, I report the findings used to answer the first research question, which asked:

What are the observable differences in the engagement of Aboriginal students when they are involved in Western science lessons and lessons that are embedded with Aboriginal perspectives?

My goal was to identify, describe and explore how the inclusion of Aboriginal perspectives in science lessons impacts on Aboriginal students' emotional and behavioural engagement in science. The results are split into two chapters. This chapter begins by providing a frequency count of the behaviours indicative of engagement and disaffection. Two impressionistic tales are then used to describe lessons in the regular science classes and the curriculum innovation science classes. Following these two impressionistic tales, I provide an interpretative commentary in which I compare and contrast the findings with respect to the differences in emotional and behavioural engagement for Aboriginal students. While this chapter examines the salient patterns of the research participants' engaged or disengaged behaviours in the science lessons, based on classroom observations, the next chapter, Chapter 6, reports the results of the analysis of yarns; conducted with the intention of allowing students to reflect on their own behaviours.

Frequency Counts

As explained in Chapter 4, the data collected using field notes, anecdotal records and ABC charts, were analysed to examine the patterns of engaged and disaffected behaviours during the regular and curriculum innovation science lessons. Observable behaviours, recorded during the 30 hours of observations (15 hour observing regular science lessons and 15 hours observing curriculum innovation lessons), were categorised, according to whether they were considered to be behaviours engaged or

disaffected behaviours (as described in Chapter 4 and set out in Table 4.1). Examples of disaffected behaviours included, such as being off task, delaying the completion of tasks or in a state of averseness (e.g., “this task is boring” or “there is nothing to do”) whilst examples of engaged behaviours included focusing on the lessons, answering questions, showing sustained behavioural involvement in learning activities, displaying a positive emotional tone. The behaviours were tallied whenever they occurred in a lesson.

Separately for observations in regular science lessons and curriculum innovation lessons, the behaviours were grouped according to whether they were indicative of engaged or disaffected behaviours with respect to: consistent focus; inattentiveness; on task; work avoidance; and verbal participation. The results, reported below in Table 5.1, grouped the occurrences of these behaviours into the three broad categories for engaged and disaffected behaviours.

The results of the frequency count, reported in Table 5.1, indicated that, during the regular science lessons, the average number of observations that were indicative of disaffected behaviours was 24: 11 for lack of focus; five for work avoidance; and eight for verbal participation (or lack thereof). The average number of observations in the curriculum innovation lessons that were indicative of disaffected behaviours was five: one for lack of focus; one for work avoidance; and three for verbal participation (or lack thereof).

The average number of behaviours indicative of engaged behaviour for regular science lessons, also reported in Table 5.1 was 13: seven for consistent focus, four for on task and three for verbal participation. For the curriculum innovation lessons, the average number of observations indicative of engagement was 39: nine for consistent focus, 14 for on task and 17 for verbal participation.

The results indicate that, for the regular science lessons, the average number of observations that were indicative of disaffected behaviour was higher than the for the curriculum innovation lessons. Conversely, the average number of observations indicative of engaged behaviour was lower in regular science lessons than for

curriculum innovation lessons. These figures indicated that, on average, the research participants, displayed more engaged during the curriculum innovation behaviours and fewer disaffected behaviours than in the regular science classes.

Table 5.1 Frequency Tally for Behaviours Indicative of Engagement and Disaffection for Regular and Curriculum Innovation Science Lessons

Behaviour	Number of Occurrences	
	Regular Science Lessons	Curriculum Innovation Lessons
<i>Disaffected Behaviour</i>		
Lack of focus/attention	11	1
Work Avoidance Behaviours	5	1
Verbal Participation	8	3
Total Observations indicating disaffected behaviour	24	5
<i>Engaged Behaviour</i>		
Consistent focus	7	9
On-task	4	14
Verbal participation	3	17
Total Observations Indicating Engaged	13	39

NB. 15 lessons Frequency–average per lesson

Impressionistic Tales

Impressionistic tales provided me with a means of describing the existing situation in a way that reflected the Aboriginal way of knowing and doing, based upon their oral tradition of sharing knowledge (Absolon & Willett, 2004; Thomas, 2005). Two impressionistic tales are used to contextualise the lessons and to develop my argument. One tale describes the engagement of the research participants that was observed during regular science lessons (before the curriculum innovation was introduced), and the other is used to describe Aboriginal student engagement during the curriculum innovation. As explained in Chapter 4, the impressionistic tales involved extracting themes that were common over a number of observations so the lessons portrayed in the tale are not related to any one lesson; rather, they are representative of a number of lessons. The impressionistic tales are followed by an interpretative commentary that explains what I observed.

Impressionistic Tale One: An hour in a Regular Science Class

When I first started teaching Aboriginal students, an Elder said to me: “Listen, my girl”, (I must have looked rather young then), “Whatever

you do, you must put Aboriginal people and their culture first. If everyone did this we would have fewer problems. Go to our people and they will tell you what is right and what is wrong.” These words have been the foundation upon which I have built a program delivering services to Aboriginal students. So, when I undertook this study, my aim was to get a clearer understanding about how to positively influence the educational outcomes of Aboriginal students.

It is the first morning of June. I am going to observe the science teacher’s regular science class – a lesson taught prior to the implementation of the curriculum innovation. I am particularly interested to see how (and if) the Aboriginal students engage in science lessons with a view to comparing their engagement later when we introduce science lessons that include Aboriginal perspectives.

New situations tend to make me nervous and, as I pass through the gates, I feel the flutter of butterflies in my stomach. It is one of those typical hot days in Perth with bright blue skies and not a cloud in sight. From my vantage point at the gate, I can see that the students are on their break, and a hodge-podge of noises, infused with the smells of sausage rolls and party pies from the canteen, bombard me as I approach. I clutch my files tightly, bracing myself as I walk into the school buildings.

The school was built in 1978 as a senior school for students from Years 8 to 12. For the last 13 years, the school has operated as a middle school catering to students in Years 8 to 10 (the Australian secondary schooling goes up to Year 12). Typically, students enrolled at this school are aged between 13 and 15 years. The reception area and school walls are adorned with Aboriginal artefacts and paintings, and an Aboriginal Community Agreement hangs on the wall next to the Aboriginal flag, with its bright, bold colours of black, red and yellow. All of this serves as a reminder that Australia has an Aboriginal history and culture which is acknowledged and recognised at the school. The science teacher greets

me at the door and ushers me in. She is understandably nervous and so am I.

There is a slight sense of urgency as the science teacher moves to make the last minute preparations for the lesson. Ten minutes later, the recess bell shrills and the stillness evaporates as 25 middle schoolers stampede in, giving way to a frenzy of activity, boisterous voices, giggles and laughs. A group of sweaty youths saunter in, footy still in hand, going over the memories of the recent game, Australian Rules football, the sport that captures the imagination of many teenage Australian boys. My thoughts are shattered by the word, "Throw!" The ball soars into the air from a student at the front to a student at the back of the class. The science teacher shouts, "Boys! Cut that out, now!"

The boys ignore the calls from the science teacher and continue to kick and throw the ball around the classroom. The science teacher raises her voice to a higher pitch, walks to the boy who now has the ball in his hand and yanks it off of him. There is a bit of a struggle as the boy tries to hold on to the ball and tries to persuade her that he will put the ball in his bag. The science teacher doesn't give in and warns that she will send him to the principal if he refuses to hand over the football. Eventually, the boy swears under his breath and hands over the ball. The science teacher takes the ball and puts it in the cupboard and turns to the rest of the class, which has become loud and disorderly and calls out, "Everyone, please take your seats."

There is both an Education Assistant and an Aboriginal and Islander Education Officer (known as an AIEO) present in the classroom, both of whom help the science teacher to settle the students into a semblance of order by steering them to their seats, asking them to stop talking and to put away their bags. The light banter between students continues as the seats are pulled out.

The students in the class are multicultural. The Aboriginal students in the class include both males and females and, as I watch them take their seats, I notice how they manoeuvre themselves to positions next to other Aboriginal students. The class is still not quiet. A bit of coughing here and there, some humming, tapping on the desk and clicking of pens.

Once the science teacher has a degree of attention she starts her lesson in a strong and steady voice: "Today, class, we are going to discuss energy." She then proceeds to ask a series of short questions about what the students think energy is, where it is found, and things that it does and how it is used. Several students are calling out answers but I notice that the brainstorming session gets minimal responses from the Aboriginal students, who are not forthcoming. There is one exception, an Aboriginal boy who shouts out an inappropriate comment, which the teacher responds to by scolding him.

The science teacher tries to involve Aboriginal students by calling them by name and addressing questions to them individually. One of the Aboriginal boys is doodling and tapping on the desk and leans over to talk to his classmate. The teacher moves towards him and asks him to pay attention. Another Aboriginal boy is resting his head on the table in a daydream, and the class roars with laughter as the science teacher calls him to attention. The boy lifts his head and proceeds to tell the class to shut up with an expletive in the same sentence. The AIEO quickly moves to sit next to the boy. The boy listens to the AIEO and, after a few words, he is quiet.

The science teacher quickly turns the question to another Aboriginal boy who gets the answer right. This to and fro of questions and answers proceeds for 10 minutes as the science teacher tries to explain the different forms of energy. She turns her back to the class and sums up the discussion by writing a quick definition of energy on the board and the key topics that they will be looking at. As she writes, the students start to

talk and, when she finishes, she turn back to the class and says, “Energy is all around us and you are going to play a short card game to identity different forms of energy.” The Aboriginal students don’t appear enthusiastic about the game. They reluctantly move into their groups, prompted by the science teacher, with the EA and AIEO joining them. The Aboriginal girls are particularly shy and need to be encouraged to join a group. They stay together, quietly chatting to each other and sharing a quick giggle about something, appearing hesitant to join a group.

Unlike the girls, the Aboriginal boys seize the opportunity to chat with mates. Some of the boys shove each other as they pass by, one launches a spitball that flies to the other end of the class. The AIEO moves quickly, cautioning them against what she refers to as ‘silly behaviour’. This warning and the proximity of the AIEO seems to help the students to focus on what the science teacher wants them to do. I notice that the Aboriginal students merge into groups, mainly with other Aboriginal students.

Once settled, the science teacher explains the activity, showing the cards with pictures on them and explaining that they will be given ten minutes to match the pictures on five of the cards to the energy that it represents. There are five lots of cards which are rotated around the groups and students are told that the group with the highest score wins.

I use this activity as an opportunity to walk around to the groups to look at the cards and to observe more closely the reactions and interactions of the Aboriginal students. Some of the Aboriginal students are still not focusing on the given task, and continue to have side conversations.

The AIEO is asking the students some direct questions to get them to focus on the activity. I note that the Aboriginal girls are reserved and silent. The science teacher, in a bid to give them positive social

reinforcement, praises the girls for joining the group, and smiles at them. But the girls turn their heads away and avoid eye contact with her. They sit quietly in the group, leaving the activity to their non-Aboriginal counterparts to complete. Partway through the activity, two of the Aboriginal girls ask the science teacher if they can leave the class to go the Girls Academy (a separate program that has been established at the school to support Aboriginal girls). The science teacher refuses the request and tells them that they can do that during the lunch break. They appear unhappy with the response, rolling their eyes, whispering to each other and cupping their hands over their mouths they quietly giggle.

A number of Aboriginal boys who are part of another group are clearly distracted by a disagreement over the ownership of a pair of earphones. The argument becomes louder and more aggressive as the boys try to claim ownership to the earphones and yank it off each other. The tussle is accompanied by muttered expletives, which is closely followed by boisterous laughter from the other Aboriginal boys. The science teacher moves in and separates the boys, removing the earphones and telling them to get on with their work. She follows this with a threat that the continued behaviour would result in being sent to the principal's office. The immediate reaction of the remaining Aboriginal boys was to call out "shame"; and "that's winyarn."² to the two boys who were chastised.

This group of boys has clearly lost focus and are not actively contributing to the group discussion. The science teacher, in seeking to remedy the situation, asks the EA to go over to the group and sit with them. She cautions the boys about their behaviour and tells them that they will receive detention if they continue to talk and disrupt the class, reminding them that they only have a few more minutes to complete the task. The reprimand quiets the rowdy boys and they sit sullenly, allowing their non-Aboriginal peers in the group to finish the worksheet.

² *Winyarn*: Aboriginal words used to refer to embarrassment

After a few minutes, the science teacher calls the students to attention, and tells them that it is now time to present the findings to the class; this involved each group appointing a leader to go to the front of the class and relaying the groups' findings. From the expressions on the Aboriginal girls' faces, it is clear that they don't want to go to the front of the class. They immediately look down, avoiding eye contact as they move to the back of the group to be masked by those standing in front.

I hear one of the girls communicate this to the AIEO saying, "That's shame!" and it has been explained to me that this is the fear of being judged by your mates, or looking silly in front of them. I look at the boys and it seems that they too want to avoid being picked to present the group's finding, and they push each other saying "you go." The reaction of the boys, however, is more boisterous than the girls, as they shove each other in an attempt to get the other person to go forward. I hear one boy say "That's coonyie"³ After much indecision amongst the members of the different groups, I noticed that none of the Aboriginal students went to the front to explain what they had decided. The activity has taken almost half of the lesson time. The students have had a quick burst of energy and the noise level has increased. The science teacher reminds them that she has two more activities to end the lesson and this prompts students to shush the others up.

The science teacher has candles and lighters in her hands which she distributes among the groups and asks them to first watch her. She proceeds to light the candle and then blows it out. She then holds the lighter above the candle in the smoke and the candle relights without the flame touching the wick. The Aboriginal boys rush over to grab the lighter to have a go. The science teacher cautions them about safety and, together with the education assistant and AIEO, walks around to supervise the students as they all try the same experiment. I notice the Aboriginal boys try out the experiment and then quickly start playing

³Coonyie: Nyoongar word meaning something is not good.

with the lighters; flicking the flame at each other. The science teacher senses the safety hazards of the lighters, draws the experiment to an end and collects them back. She then draws the students' attention to some theoretical facts about what had happened. She asks whether any of the students can provide the scientific explanation behind the experiment. After two attempts by the students, the science teacher explains the principle. I sense the students were more interested in the actual experiment than the explanation, as they start to get restless again and the science teacher's voice is drowned out by chatting and general banter.

As the activity is cleaned away, the education assistant distributes a worksheet that the science teacher has prepared. The worksheet involves multiple choice and fill-in-the-gap exercises. The students walk back to their desks and I notice that the AIEO has moved to sit next to the group of boys who were previously disruptive. Some of the boys yell out for the worksheet and the science teacher asks them not to shout and to wait their turn. The boys use this as an opportunity to slouch over their desks as they wait for the worksheet to get to them. Two of the Aboriginal boys ask the science teacher to repeat the instructions for the worksheet, so she walks over to their desk, repeats the instructions and clarifies what needs to be done.

There is about 10 minutes left before the end of the lesson. I note a sense of restlessness resurfacing as some of the Aboriginal students wander over to their bags to take out their drinks. I overhear one group of Aboriginal boys discussing whether they are going to the football academy during the break. In an attempt to capture the students' attention, the science teacher points out that those students who don't finish the worksheet on time would be required to stay in at recess to do so. Students immediately pull their pens out and put their heads down. Shortly afterwards, there are choruses of "Finished, miss!" as the bell shrills in the background.

At the sound of the bell, the students quickly put away their bits and pieces and rush out of the room. The science teacher looks at her teaching aids, readying herself for her next class of students. She looks up to me and says, “Well that’s one lesson done.” I admire her tenacity in trying to capture the interest of the classes. It was tough going trying to engage the students, and the disruptions created by the Aboriginal students did not make it easy for her. It would seem that for all her efforts, this traditional way of delivering a science lesson and managing student interaction was not highly effective in engaging students or maximising their learning.

Impressionistic Tale 2: Learning science using Aboriginal perspectives

As I drive to my research site school, I am no longer nervous but have feelings of anticipation and excitement, wondering how the students will react to an Aboriginal person taking the science lesson alongside the science teacher. The lesson today is focusing on the Physics topic of heat energy but it is being investigated using the inclusion of the Aboriginal fire-making method. I have learnt that the local Nyoongar word for fire is Karl, and I repeat this word over in my head, as I have made a mental bank of Nyoongar words that help me to connect with Aboriginal students. Today’s lesson is one of a series of lessons developed to incorporate Aboriginal perspectives into their science classes. I wait for the guest presenter in the Nyoongar Gardens at the front of the school.

It is an idyllic day. The trees sway in the soft easterly breeze and as I look around, I notice that the school is surrounded by rolling hills against brilliant blue skies. I run my hands along a hedge of iconic Australian plants and the smell from the aromatic foliage infuses the air. Lost in sights and smells of nature, I am jostled by a voice calling out “Is he here Miss?” I turn around and it is one of the Aboriginal boys from the science classes I’ve been observing.

I've been told by the science teacher that the students have been enquiring about the Aboriginal perspectives science lessons all week. She had started a lesson with them on David Unaipon, and I smile as I recollect her expression when she told me that hardly any of the students had known who David Unaipon was, even though he is featured on the Australian fifty dollar note. I don't think many people know that he was a writer, preacher and inventor and one of the first persons to break the stereotypical view that Aboriginal people were only fit for menial jobs.

The boy approaches me eagerly and I tell him that I am still waiting, but he is welcome to join me. He asks me for the name of the guest presenter and he immediately picks up that he is a relative, smiling and saying, "I think he's my family Miss". I note the tone of pride in his voice. While we wait together for the guest presenter to arrive the boy continues to talk about how his Dad and family go out to the bush to catch kangaroos and also spend time fishing.

A ute⁴ pulls up in the driveway and I can see, in the back, a cloak made from animal skin that I assume is either possum or kangaroo. It lies among other movable art forms, including a didgeridoo, bark paintings, woven baskets, skin rugs, boomerangs,⁵ woomeras,⁶ wooden shields, spears and jewellery. A small audience of students peer into the back of the ute to see the artefacts. More students have walked over with their science teachers to assemble at the front of the school in the Aboriginal yarning circle located in the bush tucker garden. The students are eager to see what's in the ute and their enthusiasm is noted by the guest presenter who shouts out, "Hey ya young fullas, come give me a hand here."

⁴ Ute: Australian slang for pick-up vehicle or utility truck

⁵ Boomerang: traditionally used by Aboriginal people in Australia. It is a curved flat piece of wood that can be thrown so that it will return to the thrower as a hunting weapon.

⁶ Woomera is a stick used by Aboriginal people to throw a spear more forcibly.

The Aboriginal boys immediately walk over to the ute. They greet the Aboriginal guest presenter respectfully, and the boy I was talking to calls him Uncle. They reach out and shake his hand, and it is evident that he's familiar to some as they launch into a conversation about who they are related to. The Aboriginal boys proceed to help the guest presenter to off-load the ute. We gather at the meeting circle and wait for the start of the lesson. The Aboriginal and non-Aboriginal students take their places on the circular stone benches and all eyes are on the guest presenter as they watch him lay out his stuff. I wondered, with students sitting in this fashion, whether there would be some pushing and shoving or elbowing, but I do not notice any of this. One Aboriginal boy calls out "Are we going to start now Miss?" indicating anticipation and an openness to engagement with the lesson.

The science teacher introduces the guest presenter and explains to the class the purpose of having an Aboriginal person taking the lesson with her today. She tells them that Aboriginal people are the original custodians of Australia and have their own way of viewing the world, and things they did and still do have a science behind them. She explains that for the rest of the term, students will be exploring this in her science classes and that she will have guest presenters to come and teach alongside her on some occasions. The science teacher requests students to be respectful of Aboriginal culture as it is sacred and tells the students that they are privileged to get an opportunity to share in this 60,000 year old culture. There is a respectful silence as the science teacher explains this, and an air of anticipation as they move their attention to the Aboriginal guest presenter.

The guest presenter is brown-skinned, bearded, of medium height, slim build, and has long hair that is pulled back into a ponytail. He's dressed casually and has a shirt with an Aboriginal logo on it. He takes over from the science teacher and speaks to the students, acknowledging that we're all meeting on Nyoongar ground. He goes on to talk about the

Nyoongar people in the area and their cultural heritage. As I look around, I observe a sea of faces, with all eyes looking at the presenter. None of the students are fidgeting or speaking to each other. They show signs of interest and engagement, with eyes tracking his every moment and bodies leaning slightly forward.

After he finishes the short introduction, the science teacher takes over for a few minutes, recapping to the class that today's lesson is still a part of their physics topic of heat energy, and how friction changes kinetic energy into heat energy. She goes on to explain that the Aboriginal guest presenter is going to help students to experience the way that Aboriginal people used heat energy in the early days.

The guest presenter has now picked up two pieces of wood, and asks the class: "Do you think you guys can make a fire from just these two pieces of wood?" The Aboriginal boys all chorus, "Yeahhhhh!" "These blokes⁷ are right. Today I'm gunna⁸ get you all to light a fire without any matches, just using these two pieces of wood." While most of the non-Aboriginal students just look at the guest presenter, the Aboriginal students walk forward and reach out for the pieces of wood that the guest presenter is offering. The guest presenter explains that this is the earliest method of making a fire that was used by Aboriginal people. He explains to the students that the first step is to build a tinder nest. He asks the students if they know what a tinder nest is. A hand shoots up to respond and I am surprised that it is the Aboriginal student who appeared distracted in the previous lessons that I had observed. He gives the guest presenter an explanation stating that it is "stuff that can light up easily." The guest presenter questions him as to what stuff lights up easily, and he answers "dry grass, leaves, bark or little twigs." He smiles as the guest presenter praises him for the correct response. The science teacher

⁷ Blokes: Australian slang referring to males.

⁸ Gunna: Australian slang meaning 'going to'.

adds her approval and tells the class that this is called combustible material and can ignite with a very little spark.

The guest presenter then asks the students to work in groups and to collect material that can be used to build their own little tinder nests. He tells them that they can do so in small groups. The students head off in different directions, into the nearby school garden and bush lands. The sun rays are beaming down on them as they dart between the trees, eagerly searching for bits of dry grass and leaves. I watch them as they wander off, especially the Aboriginal students who are ahead of the class, leading the way, like experienced trackers pointing out possible places to their classmates where some tinder can be found. Their approach is deliberate and they do not rush around, pausing at specific spots where they think the dry leaves are. The Aboriginal boys are first to reach out quickly for the bark hanging off trees, flying in the soft breeze, while others are hunched down picking up dry pieces lying on the floor. The Aboriginal girls are joining in, and I can see them point out to the other non-Aboriginal girls which direction they should go in. When they congregate in the area they have chosen, the Aboriginal girls lean in, first to gather the leaves that have accumulated in a corner behind some rocks, and I also notice that they tell the other girls that they can also pick the stalks from old flowers which can light up easily too. The guest presenter hadn't mentioned this, so I am keen to see if this works.

The students wander back to the meeting circle with armloads of material, keen to show their science teacher and the guest presenter what they have collected. As they lay their piles down the guest presenter proceeds with the next part of the lesson. He explains the process of twirling the round stick of hard wood into the notch cut into the piece of softwood. He calls the two pieces of wood fire sticks. One is a long piece of hard wood and the other is a similar piece but it is softer and has a hole in it. The guest speaker goes onto his knees and demonstrates the action to the students. After a few minutes of modelling this, he gets up

and helps students into position. Without delay the Aboriginal students in each of the groups get into position, concentrating on getting their hands onto the long stick and placing it into the notch. They begin to twirl vigorously without looking around or talking to anyone. Their eyes do not leave the task in front of them, intent on getting as much friction into the movement as possible. Team members strategically huddle around to keep the draught out while others call out words of encouragement and support and “Come on! Come on!” is echoed around.

The imagination and creativity of one group of Aboriginal students draws my attention. I notice that they have picked up tiny seed heads for their tinder nest and have this ready at the bottom of the notch to receive the embers from their vigorous twirling. The guest presenter asks the student why he has chosen to use seed heads. I note that the boy draws on his prior knowledge as he explains that his Pop had told him that in the old days, they used seeds as well. Another Aboriginal boy calls out that his Pop said they even used dried kangaroo poo to start a fire. The class breaks out into laughter, with calls of “ewww” from the girls. The guest presenter endorses the knowledge of the boy and tells them that, after they try making a fire, he will teach them how to make a cutting tool out of stone, sap and kangaroo poo. The “ewws” can be heard again.

As I look around it is clear that there is a strong desire to learn how to make the fire. Students are spinning their hands energetically, some building up a sweat. I notice there are some inventive strategies. For example, two Aboriginal boys try holding the notch down with both of their feet while the other student bears down on the longer piece of wood. In another group, the Aboriginal boys are trying to help their non-Aboriginal friends who are not producing smoke as a result of their efforts. They lean in and take over as their mates tire, using a more rhythmic action. One of the Aboriginal boys offers an explanation as he takes over, as if he doesn't want his non-Aboriginal peer to feel slighted, saying, “It's ok mate, I've seen my Pop do this.” I'm reminded of a relay

as I watch the Aboriginal students. Every team member is waiting, prepared to take over twirling the stick to keep the fire going. It's a race to see which group can get the first fire started. The quick changeover from student to student seems to be an exercise in trust, as the handover is instinctual and students are ready when it's their turn. They are all cooperating towards the same goal.

I smile to myself, thinking about how different the students are in this lesson, and what a storehouse of information they have on scientific knowledge. Soon I see a tendril of smoke emerging from the notch of some of the soft sticks, and the Aboriginal students are quick to position the dry grass to catch the embers from the friction between the pieces of wood. The Aboriginal students have taken the lead in this activity, they are not wandering around or off-task; they are fully engaged in the lesson.

The students are working in teams, and I note that the Aboriginal students are collaborating with their non-Aboriginal peers. I notice Aboriginal students making suggestions to both Aboriginal and non-Aboriginal students about how to create more friction. One suggests changing the position that they are standing in to give them more momentum. Another advises a non-Aboriginal student to maintain an even pressure on the stick and to keep it moving in a vertical position. I'm touched by one of the Aboriginal boys who calls out to his non-Aboriginal peers in the group, "Don't overdo it guys you don't want to get blisters." Another comments, "I can take over if you're tired mate." This sense of comradeship results in success as, after a while, I hear the first shout of, "I see smoke!" Soon this is followed by other students yelling out, "Mine too. Come and see ours!" Small amounts of smoke are emerging from the different groups. There are a few exhausted students who still can't get their fire going, so the guest presenter gathers them around to get a real big fire going. His skilled actions become more deliberate. Within a couple of seconds, he has a fire going. Exclamations

of delight are all around me as students shout out, “Wow!”, “Awesome!” and “Cool!” as the fire ignites.

The guest presenter then sits the students in a circle and talks to the students about what had just happened. He questions them about their physics topic, related to friction and heat energy, and explains the resistance of motion when one object rubs against another. Pointing to the two pieces of wood, he asks whether a student can explain how the heat energy was created. The extrovert boy whom I had observed in the general science class shoots his hand up and walks to the front of the group with the two sticks in his hand. He points to the first stick (that is sliding into the other) and says that the one stick is giving its energy to the other and the moving energy is becoming heat energy. The guest presenter applauds him for his response and the science teacher does too, as she reinforces the technical terms of kinetic energy and heat energy. The students are also questioned about the type of wood that is best for the fire sticks, and one of the Aboriginal students mentions that his dad told him that the old people had to look for wood that was not too heavy so that they didn't have to put in too much effort when twirling.

As the Aboriginal student walks back to sit among his peers, his mates high-five⁹ him for his efforts. He responds “shot mate”¹⁰ and moves back to his position. The guest presenter resumes his yarn and asks whether the students know how Aboriginal people used fire. Responses are quick, mostly from the Aboriginal students, as they call out a range of reasons including, signalling, clearing tracks through the bush, and keeping poisonous snakes away. One of the Aboriginal girls offers an explanation of how it was used to get animals out of the bush to make it easier to hunt them. Another Aboriginal student asks whether Aboriginal people burned the land so that bigger fires wouldn't start. Before the guest presenter can answer another Aboriginal student responds with “Yes, they did.

⁹ High-five: a gesture of celebration involving the slapping of palms.

¹⁰ Shot mate: meaning thanks or cheers mate.

That's why we didn't have that many bushfires before. But now more Aboriginal people are living in the cities and those in the bush aren't allowed to burn off the land."

I am struck by this non-linear thinking that ensues from the open-ended discussion, as I listen to the multiple responses from both Aboriginal and non-Aboriginal students. As the discussion continues, one of the Aboriginal students seems to have a burning question and has his hand up, waiting for the guest presenter to give him a chance to ask it. When called upon, he asks whether it is true that, because Aboriginal people were stopped from their fire stick farming, many of the desert plants, animals and people have died in the wildfires. With various perspectives and interpretations from the students, both Aboriginal and non-Aboriginal, I savour the way the discussion is opening up. This has provided an effective opportunity for students to consider each other's opinions and to justify their own beliefs. However, time has moved quickly and the science teacher is aware of this. The students, on the other hand, are engrossed in the discussion, with none of them fidgeting or requesting leave passes.

The guest presenter then tells the students that they will now make a small stone axe. He takes out the ingredients and places them on the ground in front of the students. There is a straight wooden stick (which I guess is around 30 to 40 cm long and about four to five centimetres in diameter), some sharp stones, dried resinous sap of the grass tree (balga), charcoal and dried kangaroo poo. He then asks for a volunteer to grind the resin, poo and charcoal. The mention of kangaroo poo seems to douse the students' enthusiasm, but some Aboriginal boys raise their hands to volunteer. The science teacher chooses one of them to go forward and start the grinding. As the boy gets on his knees to start the process, he looks at the Aboriginal girls and tells them that this was supposed to be "women's work." The class all laugh at what seems to be a stereotypical comment. The guest presenter, however, agrees with the

student, saying that in traditional times, Aboriginal women used the grinding stone and top stone to grind seeds from grasses, trees and shrubs, to release the starch for cooking, and that's how they made damper (Aboriginal bread). The boy is quick to retort "see I told youse so." The girls giggle and remark back "we know how to make damper."

The Aboriginal boy kneels down and concentrates on grinding the ingredients. The guest presenter then tells the student to take the stick that is provided, heat it over the fire, dip it into the mixed powder and to hold it over the fire again. Because of the short time frame, and for safety reasons, he uses a gas burner and reminds the students that the fires that they all worked on a few minutes ago would be used in a real life situation.

The class watches as the Aboriginal student leads this activity, building the resin coating, layer by layer, until it is over a centimetre thick, looking smooth and shiny, almost glassy. The guest presenter then asks for another volunteer to help to choose a sharp stone to attach to the stick. A non-Aboriginal boy who has raised his hand walks forward and looks through the stones, selecting the one that what he thinks will be most suitable. Both of the students then work together, using more resin to attach the stone that is already on the end of the stick. I note the collaboration and connectedness between the two students as they consult with each other on how much resin they should use and for how long they should hold it over the flame. This moment of connectedness affords me a glimpse of what reconciliation might look for the two cultures.

Once the head is attached, the two students look at the axe that they have made with pride and share in the accolades from the guest presenter. It is clear that the students are all intrigued by the fact that balga resin and kangaroo poo can make plastic glue. It is also evident that students felt that making an axe was "cool," so they are all keen to have a go.

Before they get a chance to make their axe, the science teacher moves to the front of the group and questions students about scientific principles that they have seen in operation. The responses from the Aboriginal students are quick and accurate, as they relate the traditional practices to Western scientific principles. They positively identify that the mixing of the kangaroo poo and the resin involved a chemical reaction and that the heat was the catalyst for the reaction. One Aboriginal student points out that what the kangaroo eats impacts on the process too, and that the grinding process breaks down everything to release a “gluey substance, and the heat applied hardens it.” The discussion suggested that the essence of how science works and the practical and inventive way in which Aboriginal people used it was dawning on the students.

As the students make their small axes, I am again struck by the cooperation among the students, their attentive listening skills and critical thinking. This is certainly an epiphany for me, as I see the Aboriginal students in a different light. Their avid interest and genuine enthusiasm reminds me of the great Benjamin Franklin quote: “Tell me and I forget. Teach me and I remember, involve me and I learn.” At the end of the lesson, the science teacher collects them for safety purposes and the bell sounds for the next lesson. It would seem, however, that the students are reluctant to leave. They linger around the guest presenter and ask whether they can help him to pack away. The science teacher gives permission for a few students to help him, while the others are moved along.

Today was well spent; I enjoyed this lesson with the Aboriginal students. It was as if we have had a secret ingredient in the classroom that had been guarded for many years and it has now been released to refresh us. The Aboriginal students had been able to draw on their prior knowledge and familiarity within their own cultural and family contexts. I shut my journal and make a note to self; one size definitely doesn't fit all.

Interpretative Commentary: Aboriginal Student Engagement Pre- and Post-Innovation

In this section, the results are presented as an interpretative commentary to discuss the observable differences in the engagement of Aboriginal students when they were involved in regular science lessons and lessons that are embedded with Aboriginal perspectives. The two narratives provided above serve as a reflection of the typical student responses in the two lesson types and focused on the patterns of interactions and behaviours of the research participants within it. The classroom observations, as explained in Chapter 4, were conducted with the intention of seeing, from a third person perspective, how the research participants engaged in regular science classes and then in a curriculum innovation of lessons embedded with Aboriginal perspectives. It was envisaged that the patterns of interaction and behaviour which emerged in the two contrasting lesson types may provide some insights into reasons for Aboriginal students' disengagement in science subjects. I did this by looking for patterns and contrasts in both the regular and curriculum innovation lesson in order to examine the research participants' engagement which defined as 'energy in action' (Appleton, Christenson, Kim, & Reschly, 2006, p. 428) represents the connection between an individual and the activity in which one is involved.

In comparing and contrasting the actual lessons during the regular science lessons and the curriculum innovation as factors impacting student involvement or off-task behaviour, many differences were apparent. The regular science lessons adopted a more "chalk and talk" approach, whereas the curriculum innovation lessons moved away from this direct form of teaching to a more collaborative form of learning where students took greater control of their learning. In the regular science lessons the traditional, teacher-directed method of learning, where the teacher spends more time standing at the front of the class, directing learning and controlling classroom activities, was evident. In contrast, the lessons embedded with Aboriginal perspectives were more innovative using experimental styles of teaching. These included basing learning on the students' interests, giving them more control over what happened in the activities, for example, the fire and tool making activities and the reduction of memorising, worksheet based activities. The learning in the

innovation classes was more of a discovery for students; which appeared to suit the research participants. In contrast to the general lessons, the innovation lessons also gave the Aboriginal students and opportunity to draw on their past experience and existing knowledge to make connections with what they were learning. Finally, during the innovation lessons, students were more active, as opposed to the regular lessons, during which, student were required to sit at their desks, listening to what was being taught.

In the regular lessons, the teaching was more regimented and the collaboration and group learning was more related to answering worksheets; with an emphasis on remembering and recalling the concepts taught. The observations, when contrasted with innovation lessons, suggested that this setup generated more disaffection than engagement for the research participants (a point discussed further in this chapter). Whilst it is noted that learning can occur whether students are “active” or “passive”, the observations suggested that the research participants were more engaged during the curriculum innovation lessons in which a more flexible inquiry-based approach, which linked the science curriculum to the background knowledge of the research participants, facilitated more engagement.

These observations do not suggest that the regular science lessons were ineffective nor that there is only one correct way to teach. Rather, the findings suggest some practices, such as the inquiry-based lessons in the curriculum innovation, were more effective than the regular traditional science lessons in engaging the research participants. A balanced approach of science teaching to inspire curiosity and innovation as well as teaching the mastery of concepts is advocated and ties in with the philosophy of this study that both western and Aboriginal systems of knowledge can be taught side by side.

The same can be said of the behaviour management strategies adopted by the teacher, which are important factors that impact on the research participants’ engagement. How a teacher manages his or her classroom is important in creating an effective learning environment; having the potential to promote a positive, caring classroom community that encourages student learning, positive peer and teacher

relationships and self-motivation. Questions continue to surround whether we are ‘fixing’ the students or ‘fixing’ the system or whether tough or punitive approaches to behaviour (such as writing names on the board, taking away a student’s lunch time, or handing out detention) are indeed effective or, in the long term, exacerbate student disaffection.

Although questions that surround behaviour management were beyond the scope of this study, my observations indicated that in the regular science classes the teacher’s behaviour management strategies were geared toward ‘fixing’ the students and extinguishing disaffected behaviour. During these lessons, behaviour management focused on warnings and sanctions with the teacher trying to maintain classroom control through a routine with signals to indicate that it was time for certain behaviours to be performed. The classroom environment was also modified via placement of desks, tables, supplies, etc. to minimise off-task behaviour and allow the teacher to circulate around the students.

In the curriculum innovation lessons, however, the teacher provided more varied ways of presenting the lessons; notably with the inclusion of the Aboriginal guest presenters. The innovation lessons involved group activities and discussions and students were not confined to the physical environment of the class; with many lessons being conducted outdoors. This more flexible approach appeared to enhance relationships between the teacher and the students and students to students (discussed further in Chapter 6). The lessons also included topics that were relevant and teaching strategies more congruent with Aboriginal ways of knowing and doing (which is elaborated further in Chapter 6).

Throughout my observations, I looked for patterns to create a picture of what I had observed. In comparing the Aboriginal students’ engagement in regular science lessons with their engagement in the innovation lessons, a variety of contrasts became apparent. The trends that emerged, evidenced in patterns of behaviour, were indicative of more positive engagement during the innovation lessons, suggesting that Aboriginal students’ engagement could be enhanced when they learn within a

curriculum that is connected to their culture. In Table 5.2, I condense these observed behaviours to give an overview and discuss the variances in the following section.

Table 5.2: Summary of the observable trends in Aboriginal students' behaviour in regular and innovation lessons

Regular Science Lessons	Innovation Science Lessons
Traditional approach, regular mainstream science curriculum, science teacher provided some direct instruction, whole class question-and-answer session. During the question-and-answer session, the science teacher usually asked questions, then students raised their hands to volunteer answers. Science teacher assigned activities for individual work and group work, some experiments were included.	Science teacher and Aboriginal guest presenters provided science teaching with an adapted science curriculum which included Aboriginal perspectives and a more experiential way of learning. Cooperative, hands-on learning gave students more autonomy and encouraged science teachers as co-learners.
<i>Emotional and behavioural components</i>	
Occasions when students did not adhere to behaviour rules were frequent. Students had to be reprimanded on numerous occasions for misbehaviour.	There were no incidents of misbehaviour.
Students were often late to class and also made requests to leave the class.	Students arrived on time and moved quickly and quietly to assigned activities.
Students were reluctant to help, set up equipment, and pack away.	Students walked eagerly to the Aboriginal guest presenters to help with carrying items and packing away.
Evidence of student interest was low, as demonstrated by little note taking, and low attentiveness, as students had to be repeatedly called to attention by the science teacher.	The degree of attention, curiosity, interest, optimism, and passion was considerably higher and students did not need to be brought to attention by the science teacher. They willingly participated in activities.
<i>Verbal behaviour and Interactions</i>	
Passive answering of questions: students prodded by science teacher to answer questions.	Active answering of questions: students voluntarily answered questions and also posed self-generated questions.
Careful observation revealed that laughter/humour occurred when students were laughing at the expense of others/poking fun at others/emulating science teacher's accent. Students often shouted out answers	Light hearted non-malicious jokes were overheard, and laughing at jokes told by guest presenters.
Audible sounds, such as whistling, humming, forced burping and other funny noises.	Students volunteered to answer questions and waited their turn with hands raised and used positive emotional tone.
Private and often rowdy verbal exchanges were observed during lessons, and talking out of turn. When it came to handing in their work, students offered incomplete efforts.	Students used calm voices, respectful language and courteous remarks, especially in the presence of Aboriginal guest presenters. Respect was spontaneous and the science teacher did not have to request this from them. Students focused their attention on the activities and lessons and were keen to use their time to enhance their work, e.g. the posters they created on Aboriginal inventor David Unaipon. Meaningful conversations were overheard.
Students needed an AIEO to keep them on task. Had to be prompted to complete tasks.	Students worked independently on many activities. They did not seek out help from the support staff. They were not forced to participate in the activities.

Regular Science Lessons	Innovation Science Lessons
<i>Physical behaviour</i>	
Distracting other students, keeping other students off task. Throwing objects at other students when the science teacher wasn't looking/playing with objects/folding paper/doodling/scuffing shoes on the ground, repeatedly clicking pens/aimlessly flipping the pages of a book. Poor eye contact especially from the girls/physicality from the boys — incidents of physically touching/shoving other students were observed on numerous occasions.	Controlled responsible, actions observed were directed to the lessons. Students' body language was engaging as their eyes followed the science teacher and guest presenters' actions. Their focus was on what was happening and they were not looking around or fidgeting. Nods of agreement were more noticeable.
Showing up late/leaving early/walking around the classroom.	Students did not request to leave the classroom during the innovation lessons unless it was to keep an appointment.
Students leaning on hands, slouching in their seats/heads on desk. Students out of chair/turning around in chair/fidgeting in chair/swinging feet.	Students did not display any of these actions during the innovation lessons and used every lesson to get involved in what was happening. As many activities were hands-on, students immersed themselves in carrying out instructions, making implements and working out ways to solve problems.

These differences in observed behaviours are discussed below in terms of emotional and behavioural engagement.

Emotional Engagement

When observing the differences in Aboriginal students' emotional engagement during the regular and innovation lessons, I focused on their pride in their work, their level of enjoyment of the science lessons and the extent to which they went about their learning in a positive and interested manner. As described in the first narrative, during the regular science lessons, the research participants generally displayed lackadaisical attitudes coupled with disinterest and boredom. This was evidenced by many of the participants shying away from active participation and often labelling some activities as *coonye* and boring. The lack of eye contact from the girls with the teacher, the physicality of the boys (who were more interested in finding distractions) and in the constant calling out of "This is boring Miss" were all evidence of the lack of emotional engagement during the regular science lessons.

I also observed that the inattentiveness of the Aboriginal students required the explanations to be repeated, as they had either not understood or not paid attention in

the first instance. I noted that, although the science teacher constantly asked questions to ensure that the Aboriginal students had grasped the concepts, the students generally put their heads down and did not respond. In many instances, throughout the regular science lesson, the teacher sought support from the education assistant and AIEO.

During my observations, I noted that the students used a range of avoidance tactics and made requests to leave the classroom to go to the football academy or to the toilet. I often heard students say that they were feeling sick but later when I was out of the classroom, I saw the same students kicking the football without any signs of the illness they had complained about in the class.

These students during the curriculum innovation, however, demonstrated a more positive demeanour and responded well to directions about ‘finding a partner’, ‘making a circle’, or ‘sitting in groups’. They were willing to be included in activities and did not ‘hang back’ as if they were not part of the group. In the regular science lessons some of the students would rebut approaches from the teacher or the AIEO but during the curriculum innovation lessons task engagement increased and they quickly grasped what the rest of the class were doing and joined in.

During these lessons, I observed that sustained participation in the learning activities appeared to be difficult for many of the Aboriginal students. They became restless and appeared to struggle to concentrate or stay focused on the tasks. The students appeared frustrated if they did not understand concepts, and gave up if the work was too difficult.

During the innovation lessons, the same Aboriginal students behaved quite differently. Throughout the innovation lessons, described in the impressionistic tale, they were more forthright and less shy with the science teacher and guest presenters. Overall they demonstrated more of a “yes I can do it” attitude than the “this is too hard” attitude that was present during the regular science lessons. These same students showed more enthusiasm, optimism and attentiveness during the innovation

lessons, often indicating that the lessons were “*dardy*.”¹¹ They displayed their interest by actively participating in all of the lessons; they were curious and interested to find out more about things by asking questions. In some cases, they brought Aboriginal artefacts from their homes and asked their family members to help with science activities. In the innovation lessons, the number of requests to leave the classroom were reduced. In fact, students often lingered after the lessons to continue chatting to the science teacher and guest presenters, whereas in regular science classes, they would leave the classroom as soon as the bell sounded.

The students’ positive disposition was also noted in their manners and politeness, such as simple acts of courtesy and respect for the guest presenters. On many occasions, students called the guest presenters “Uncle,” a sign of respect in Aboriginal culture.

The Aboriginal students appeared to be more confident during the innovation lessons with both the guest presenters and their non-Aboriginal peers. In their interaction with the guest presenters, they behaved appropriately, used appropriate language and mannerisms and communicated with them more easily. The conversations between them appeared relaxed and engaging.

The interaction between the Aboriginal and non-Aboriginal students appeared to increase during the innovation lessons, with the students communicating and collaborating more. Smiles and laughter between the students were visible as they shared activities and praised each other on completion of tasks. The element of enjoyment was more visible and audible, as the Aboriginal students readily helped out in activities and assisted their peers. During the activities, they asked each other questions and explained things to each other before asking the guest presenter or teacher what to do. The reliance on each other’s strengths, working as a team and incorporating each other’s perspectives seemed to cement a bond between the students.

¹¹*Dardy*: Australian Aboriginal slang meaning something is really good

Behavioural Engagement

Throughout the regular science lessons, the Aboriginal students' behaviour was not consistent with what is considered acceptable or appropriate in a classroom. Fundamental behaviours such as listening to the science teacher, following classroom rules (such as arriving to class on time), responding to teacher-initiated directions and questions, were not always observed. In the regular science lessons, the Aboriginal students exhibited a range of inappropriate behaviours that included swearing, squabbling between peers, talking while the science teacher was talking, throwing objects at each other, shouting out, fidgeting with things, leaning back in their chairs, looking at other students, whispering, daydreaming and laying their heads on the table. These I interpreted as signs of disaffection.

Recording whether they slouched over their desks, tapped on the desk, or doodled on their notepads helped me to create a more complete picture of their engagement and focus. The boys would often lean their chairs against the wall, fidget and take on the mask of the "cool dudes," uttering expressions like, "Yeah, boy..." and "What's up, *dude?*" and repeatedly sharing fist bumps.¹² Being seated in rows seemed to contribute, allowing some of them to move to the back of the class, where they continued to interact with their mates away from the science teacher's direct view. Other students pushed or kicked the chairs of the students in front of them or tried to distract them from the lessons. Some of the students appeared to find it difficult to work during instructional time and were observed to frequently get up, walk around, or solicit attention from their peers. This disruptive behaviour was often accompanied by distracting physical movements and the forbidden acts of eating, drinking or chewing gum in the classroom. During one of the observations, I witnessed a real classroom scuffle and, in numerous observations, I saw work being crumpled and thrown away when the students became frustrated.

This disinclination to behave in an acceptable fashion and show a connection to the learning opportunity in the regular science lessons changed to more positive conduct during the innovation lessons, where the same students were observed to be more

¹²The action of making a fist and bumping another person's fist as a celebratory action.

willing to participate in activities, listen attentively, follow instructions carefully and refrain from coarse language. The noises, such as tapping and clicking of pens on the desk, bouncing knees (that shook the desks) whistling, humming and doodling ceased. The frequent getting out of chairs or wandering around the classroom, wasting time in the corridors and catching up with mates was transformed to more purposeful actions such as walking over to meet the guest presenters and helping them with carrying resources.

Many of the innovation activities were held outside of the classroom. One might assume that the students would need extra supervision than in the regular science lessons, but this was not the case. I observed that the EAs or AIEOs did not have to tag along with the Aboriginal students to monitor their behaviour. On the contrary, the Aboriginal students handled their freedom in a responsible manner. For example, when trying to find various sorts of tinder for fire making, they stayed on task.

What was also noticeable was that during the innovation lessons, the Aboriginal students were better able to self-regulate their behaviour without being prompted by an AIEO. The previous physicality of those Aboriginal boys who were observed pushing and shoving each other during the regular lessons was replaced by team work during the innovation lessons. Unlike the regular science lessons when there were disruptive side conversations, during the innovation lessons the same students were asking questions about how to carry out tasks and asking the guest speaker whether they were carrying out the activities correctly.

The observations in both regular and curriculum innovation science lessons indicated that embedding Aboriginal perspectives in the science lessons had a positive influence on these Aboriginal students' emotional and behavioural engagement. The next chapter examines the results of the analysis of the yarns to help to explain reasons for these changes.

Chapter 6

Results:

Yarning about Science Engagement

In this chapter, I present the results for the analysis of the data that was collected using yarns with the research participants. Data collection during this phase was used to examine the possible factors which influence the engagement of Aboriginal students in science. These results were used to address the research question:

What are the possible reasons for the increased engagement of Aboriginal students in science when Aboriginal perspectives are embedded into a prescribed school science subject?

When the science teacher and the Aboriginal students who participated in the study reflected on what had influenced their science engagement during the curriculum innovation lessons, four main themes emerged:

- Fostering connectedness;
- Strengthening Aboriginal students' confidence;
- Appealing to Aboriginal students' learning strengths; and
- Changing perceptions about science.

In this chapter, I describe each of these themes in turn.

Theme 1: Fostering Connectedness

A major theme that emerged during my analysis of the data was that of connectedness. In this study, the term connectedness was used to describe the feeling or awareness of or responsiveness to being united, linked or joined together. This theme, which involved unity and relational bonding, was used to describe factors related to increased connectedness: with the curriculum; between the teacher and the Aboriginal students; between Aboriginal and non-Aboriginal students; and between the teacher and the parents and community.

Connectedness to the Curriculum

The concept of connectedness, as described in this section, is related to the way in which Aboriginal students reacted to the experiences provided during the curriculum innovation. The term connectedness, therefore, was used to depict the bridge that Aboriginal students experienced when exposed to a curriculum that reflected their Aboriginal cultural knowledge, as opposed to the detachment observed in general science lessons. This section reports the results of analysis of the yarns with respect to Aboriginal students' connectedness to the curriculum from the teacher's and the students' perspectives.

Science Teacher's Perspectives

During yarns with the science teacher, many of her comments were related to the theme of connectedness. The science teacher indicated that she acknowledged the chasm that was experienced by Aboriginal students when they studied science before the curriculum innovation.

I felt a bit uninformed when I first started taking part in this trial. I mean, I should have done more research and professional learning because when the curriculum innovation lessons began, I realised how different it must be for Aboriginal students sitting in a purely science classroom. I began to learn that Aboriginal knowledge is considered to be sacred and most of the information has been passed down through stories. Aboriginal people have learnt through an oral tradition, telling stories and experiencing things. And their whole system is holistic and subjective. The science that I have been teaching Aboriginal students is so different, you know. So formal, everything must be written down; we analyse, hypothesise and have to be very objective in everything we do.

The teacher went on to say that, during the curriculum innovation lessons, she realised that, by connecting her mainstream science teaching to Aboriginal traditional knowledge, she was able to start the process of bridging this chasm:

The curriculum innovation lessons were an eye-opener to me. I could see that there were many differences between Aboriginal and non- Aboriginal knowledge systems, but I could also see that it was possible for each system to be connected for the Aboriginal and non-Aboriginal students to get a better understanding. This was evident, you know, in the spear throwing lesson on the oval. From the outside, it would seem that the students were just throwing spears in the air for fun. The students didn't worry about exact measurements of how far the spear was thrown or about the wind direction. When we got back to the class we discussed what made this spear that Aboriginal people invented fly through the air so effectively. We then began discussing it in "Whitefulla" or "*wadejella*"¹³ terms, as the kids call White people. Terms like velocity, speed, wind direction, force were some of the science terms we brought into the discussion. The actual spear throwing session was an excellent way to engage the students, which made the scientific explanations less boring and more relevant.

The teacher found that, when she related her mainstream science curriculum to Aboriginal knowledge, the Aboriginal students were using their history, culture and background to recognise and connect to problems, and thought and acted strategically to solve them. To this end, she stated:

The Aboriginal students amazed me during the fire making lessons; thinking outside the box for different ways to get the fires started. Some adopted different positions to get their fires started, others tried different weight and textures of tinder and some told other students to gather around to keep the breeze out. I wondered how they were so adept at this. The students seemed amused by my surprise and in a matter of fact tone, one student said: "Miss, we know about this. Nyoongars have been using fires for many years, for hunting, cooking, staying warm and burning off the land to prevent bush fires. We also tell stories and have yarns and dances around the fire." I felt a bit silly for not doing more research and taking it

¹³ *Wadjella*: Term used by Aboriginal people to refer to a White person/people

for granted that the Aboriginal students had become westernised and had forgotten their traditional practices.

The teacher said that once she began to compare Aboriginal scientific concepts and establish connections for the Aboriginal students, it increased their engagement in science. She said that when she began to connect the understandings that her students' parents and grandparents had acquired over the years, predominantly through observations and associations with various places, this seemed to spark the interest of the Aboriginal student's:

It was only through this curriculum innovation that I realised how much Aboriginal knowledge is based on the Aboriginal students' physical, social and spiritual awareness, which informs their lives and the survival of their ancestors for thousands of years. After watching and listening to the Aboriginal guest speakers and using more Aboriginal science based resources, I started providing more experiential based activities for my students. I then began to see the Aboriginal students engaging in a cognitive process of constructing relationships between what they already knew and the concepts of science that I was teaching them. For example, in term one, I was scheduled to teach students about the nature of energy, the way energy interacts with different materials and its different forms and effects. I then looked up ways in which I could connect it to energy sources used by Aboriginal people. The Aboriginal students were way ahead of me in trying to come up with sources, and rattled off how Aboriginal people used shade and shelter and how they adjusted what they did during different seasons to conserve energy.

According to the teacher, this connection between the science curriculum and Aboriginal traditional knowledge permeated the entire curriculum innovation period, as both the teacher and Aboriginal guest presenters made deliberate attempts in all the science lessons to bring together knowledge from two different worlds.

According to the science teacher, throughout the curriculum innovation period, she deliberately linked her science topics to appropriate Aboriginal perspectives. She

touched on aspects of astronomy, mentioning to students how Aboriginal people knew about the connection of tides to the moon, and how Aboriginal people didn't have maps or any navigation tools but travelled across vast lands using the stars as their compass. She incorporated knowledge about the Aboriginal seasons which differed from the seasons in Western culture, and she and the Aboriginal guest presenter explained to students how Aboriginal people used local sightings like sharks breeding and wattle flowering as indicators of a particular season.

The teacher commented that she became excited about the valuable information that she had found during her web searches for Aboriginal perspectives across the curriculum, many of which she found she could incorporate into her lessons:

While on the net, looking up how I could connect the empirical knowledge held by Aboriginal people and explain it clearly to students, I came across the Bureau of Meteorology Indigenous Weather Knowledge website. I was so excited because I could show my students how the Government of Australia is using Indigenous climate, weather and culture to explain environmental changes and to provide strategies for sustainability. After I showed the students this website, they were totally interested in surfing this website and when I looked at their computer screens, they were always on the site.

The science teacher felt that, by connecting the science curriculum with Aboriginal science, she “created opportunities and conversations for her students to become critical learners and allowed them to identify and evaluate how Aboriginal people interacted with their environments”. The teacher recollected some of the ways in which the curriculum was connected with Aboriginal knowledge:

The Dreamtime stories that the guest speakers introduced in our science lessons, about creation, how natural elements were formed, or how species came to be, was knowledge I used to compare the science take on how life started. This stimulated interesting conversations and debates on evolution, but it also provided students with knowledge of Aboriginal hunting locations, animal behaviours, the oceans, the stars, and basically how

Aboriginal people interacted with their environment. All this helped, because when we were discussing land management practices and sustainability, I found that the Aboriginal students had a sense of interconnectedness to the land and were providing responses like “cool fires” and burning practices to prevent bush fires, and how these fires should be done during the dry season of May, June and July. The students provided critical evaluations of why you don’t burn land when it is harvest time, why you don’t burn too early as bigger bushes grow after the fire, or too late, which makes the trees split open. I realised that these were scientific conversations discussing the ecosystem.

According to the teacher, when Aboriginal perspectives were embedded, the Aboriginal students were able to use background information that had been passed down from their parents and grandparents to answer questions more logically and critically. The Aboriginal students’ responses were contextualised by the traditional knowledge and histories they held. For example:

When we were studying the concepts of atomic structure and electron arrangement and how these can be used to group materials, an interesting link was made between the modern fibreglass that many students are familiar with and bush glue. We were actually fortunate because one of the Aboriginal guest presenters actually made this glue with the students from scratch, and I was able to explain the chemical properties, reactions of chemicals and chemical changes from a scientific perspective. Having the Aboriginal students see this real connection was very helpful because when I teach them the chemical symbols, formulae, equations and the periodic table etc., it is sometimes a bit abstract to them, but doing the bush glue lesson helped me to make the description of investigating and predicting change in materials more practical and believable.

The examples provided in this section are a selection of how embedding Aboriginal perspectives in science lessons fostered increased connectedness of the Aboriginal students to the curriculum. The next section reports the findings from the students’ perspectives.

Aboriginal Students' Perspectives

Observations and yarns with the Aboriginal students who participated in the curriculum innovation left me in no doubt that they preferred the science lessons that included Aboriginal perspectives. The Aboriginal students who were involved in the yarning sessions all expressed that they found the curriculum innovation science lessons to be more relevant to them. One of the students summed up how many of them felt, saying that the lessons were more meaningful to his life and in stark contrast to the negative views of Aboriginal people and their culture that he so often had previously heard:

I just think, hardly anyone cares for our culture. Our parents and Elders tell us that we have the oldest living culture in the world. But our teachers never tell us this. When we see the papers, it's about all the bad things about Aboriginal people. When we are on the trains, people stare at us. Many people think we always lazy and drunk, we always fighting and they think we have all been to jail. On Facebook people disrespect our culture. One of the many ways we connect is with our traditional corroboree dances,¹⁴ but non-Aboriginals [sic] are saying it as "car robbery" and calling our land "Liquorland."¹⁵ It is hard for us to stay proud in our culture. If we have more culture in our school then we can be proud and other students can know that Aboriginal culture is good and not so bad. I don't like science but if the science teacher can make it more interesting like how the Elders came in and taught us, then I'll like it. [Student 1]

Linking the prior knowledge of the Aboriginal students to new knowledge appeared to make a difference to the Aboriginal students' views of the science lessons. The students all remarked that they recognised a lot of the information that was provided during the curriculum innovation lessons, as they had been exposed to it when they were growing up. It appears that this familiarity made it easier for them to activate and transfer this existing knowledge to the curriculum innovation lessons. For example, one student said, "we could learn better and we learnt more than sitting in our science classroom Miss. The teacher normally fills our head with all that science

⁴ *Corroboree*: An Aboriginal word for an open cultural performance or dance.

¹⁵ *Liquorland*: The name of a chain of retail outlets that sell alcohol.

stuff that I don't get sometimes" [Student 5]. Another commented that "It was cool stuff that we knew so it wasn't hard and boring" [Student 8]. Another student said:

I paid attention more, because the teacher was not going on and on about all the questions we had to answer in the worksheets. She was asking us to tell her about our stories with our families and our culture. We don't have a lot of things that are in books so we like to talk about real life things. [Student 11]

Yarns with the students indicated that asking them about their prior knowledge and using this information in the curriculum innovation lessons was highly valued. The yarns indicated that this increased students' interest and participation in and enjoyment of the science lessons. To this end, one of the students said:

Our teacher gave us a project so we can write about our own experiences and also ask our family members for their ideas. I chose the bush medicine topic because I used some before and my Nan taught me how to make some. [Student 10]

Another student, in his remarks about what he liked about the lessons in which Aboriginal perspectives were included, said:

It was nice to learn about the scientific names which are sometimes hard and then also learn about the Aboriginal names for things. Like I learnt that the Ringtail Possum is called Wawding in Nyoongar and the Blue Whale is Mamong, the grass tree is Balga and Kangaroo Paw is Kurulbrang. Also I didn't know that much about Aboriginal astronomy, how Aboriginal people have six seasons and used plants and foods for medicines. [Student 5]

Yet another student expressed the connections made between the science curriculum and his own background:

I learnt about carbohydrate foods in science but didn't know that Aboriginal people got their starch from the milkmaid plant roots which have a lot of flesh and also some roots can be ground into a paste to make

cakes. We make damper with flour nowadays but in the old days they had to use seeds and crushed them and then baked them. So yeah old and new ways are good to know, it's more interesting. [Student 7]

Connectedness to the Teacher

As with connected to curriculum, the notion of connectedness to the teacher refers to the relationship that the Aboriginal students established with their teacher during the curriculum innovation lessons. This section examines both the teacher's and the students' perspectives on those elements that made the Aboriginal students feel more connected to the teacher.

Science Teacher's Perspective

The science teacher found that the curriculum innovation fostered a closer connection between herself and her students. Analysis indicated that the curriculum innovation lessons promoted relationship building as they provided opportunities for the teacher to get to know her students, their family background and culture. The curriculum innovation lessons also enabled greater interaction, which, according to the teacher, "allowed the Aboriginal students to see her in a new light." She commented:

I think the relationship between me and my students definitely changed. In my regular science lessons, I was that voice of authority, you know, the teacher in charge, and I was just teaching the kids every day, the same science topics, the same process, of worksheets, tests, homework you know. But the curriculum innovation lessons changed all that because the lessons became more varied. We spent a lot of time outdoors and doing more hands-on stuff and this kind of created a more relaxed atmosphere, I spent more time chatting with the kids and doing things with them. Listening to the Aboriginal students' stories actually changed our relationship as they could see I was willing to hear their stories and we actually got closer.

According to the teacher, embedding Aboriginal perspectives into science lessons impacted on her relationship with the Aboriginal students in her class. The teacher felt that the curriculum innovation lessons gave her the flexibility to interact more closely with the Aboriginal students that wasn't available within the confines of the regular classroom. She reported that the Aboriginal students made a stronger personal connection with her, which was evidenced by them approaching her and talking to her more frequently, opening up about personal problems and asking for advice. These were things that had not occurred prior to the curriculum innovation, as they had preferred to speak to their AIEO about their problems. Even once the curriculum innovation lessons had finished, the students continued to seek help from the teacher when they were struggling with difficult questions. The boys would approach her to share their football successes, and the girls often approached her when they were experiencing personal issues. The teacher felt that this relationship was fostered through the curriculum innovation lessons, where she got to know the students and their families more personally. She stated that:

The students seemed to have a new found respect for me. Like I was welcomed into the "clan" you know. From the moment I started including Aboriginal knowledge and Aboriginal people in my lessons, our relationship changed for the better. The Aboriginal boys were less rude and their behaviour improved. They would offer to help me more and the girls were not as shy to talk to me. In fact our conversations were fun and we laughed a lot.

The teacher also commented that there was less conflict between her and the students with respect to behaviour and getting the work done. This new closeness and respect seemed to impact on the students' attendance in her classes. During the curriculum innovation lessons, the students were no longer avoiding her class or requesting to leave the classroom as they had done previously. The teacher felt that embedding Aboriginal perspectives in the science curriculum helped her to get to know and better understand the Aboriginal students, which led to stronger connections with them.

Aboriginal Students' Perspectives

The Aboriginal students who were involved in the yarning sessions also expressed that they felt a more positive connection to their teacher. These students felt that they had established a more positive relationship with her during the curriculum innovation lessons. The results indicate that there was increased respect for the teacher for taking the time to include their culture in the science lessons. Further, they found their science teacher to be more approachable and friendlier during the curriculum innovation lesson settings. Additionally, the students appreciated that the teacher had given them a degree of autonomy and freedom during the lessons, thus earning her kudos in the students' eyes. For example, one of the students said:

I didn't know my teachers could be that deadly¹⁶ and join us in spear throwing and making the tools and the fires. In the classroom they are different and stricter; but on the oval they were having yarns with us, and joked with us too. It was deadly as. [Student 15]

During the yarns, students frequently commented that their behaviour had improved and admitted to being naughty in the regular lessons and "mucking about" because they "didn't care." In the curriculum innovation lessons, the students expressed that they felt more respected and valued because it was, as one student said, "about them," and having their teachers "do things with them was far better." The student went on to say:

It was nice when our teacher came out in the oval with us. She was more relaxed and even tried making a fire, sanding the boomerangs and throwing a spear. We spent time sitting on the ground, just yarning about stuff. She hadn't done that before. Normally she's pretty stressed out with us, but we can muck around too so we don't blame her for telling us off. She has to get lots done, with our assessments and reports so she doesn't really have time to have a yarn with us. [Student 7]

¹⁶ Deadly: Aboriginal word meaning awesome, fantastic or great

Connectedness between Aboriginal and non-Aboriginal Students

In this section, the term connectedness is used to describe the improved relationships between Aboriginal and non-Aboriginal students, and to portray the sense of coming together of Aboriginal and non-Aboriginal students as they engaged with Aboriginal cultural knowledge in the science lessons. This section reports, separately, the results of analysis of the yarns of the teacher and the students to examine how these relationships were built and how it fostered the process of reconciliation.

Science Teacher's Perspectives

Social connections and collaborative work with peers was highly visible during the curriculum innovation lessons, as was a closer connection between the Aboriginal students and the teacher, as explained in Chapter 5. According to the teacher, embedding of Aboriginal perspectives into her science lessons facilitated a more socially inclusive educational context during the science lessons. The teacher commented that the curriculum innovation fostered:

... an atmosphere of connectedness and inclusivity because the curriculum innovation showed the students that they needed to recognise and value everyone in the learning process as they don't all have the same experiences or beliefs. Both Aboriginal and non-Aboriginal students could better appreciate where each culture had been and where it was going.

She saw also that her non-Aboriginal students gained greater insight into Aboriginal culture and life and spent more time with their Aboriginal peers, and they learned from each other, which in turn facilitated reconciliation and built relationships.

The teacher acknowledged that the process of reconciliation was not easy and that it requires a change in mindset and attitudes. She felt, however, that the curriculum innovation lessons constituted a small attempt at starting the process in her class, and quoted examples of how the curriculum innovation connected all students and promoted empathetic identification with Aboriginal culture and people:

Connecting students to each other's culture and getting them to respect each other's cultures is not easy when you teach hundreds of students each

day but I guess as teachers we've got to try and it's our role to do so. Taking part in this trial kind of forced me to consciously try to use activities and strategies to promote a connected culture. We did this through more discussion, which kind of broke the "us and them" mentality, you know. I noticed that students learnt to listen more to each other's stories instead of giggling and being stupid or making fun of things and there was more acceptance and respect. Some lessons made me see this clearly. The time the students had to blow bubbles into the water to learn circular breathing to play the didgeridoo, some of the noises were a bit strange and the facial movements too, and seeing Aboriginal men painted and dressed only in a piece of material tied around them, could have resulted in laughing and teasing, but none of this occurred. There was an element of respect from all the students and also appreciation as they mentioned to me that "those guys were brave to show off their culture."

According to the science teacher, making meaningful and thoughtful connections during the curriculum innovation lessons provided Aboriginal students with opportunities to learn collaboratively and to establish relationships. She recalled:

The day we were working on the lesson on heat energy really showed me a different side to how the Aboriginal and non-Aboriginal students can work together. In my normal science lessons, the Aboriginal students mainly stick together in their own friendship groups, but during this trial, they ventured out of their groups and approached non-Aboriginal classmates to clarify what they had to do. In return, the Aboriginal students would break down and clarify instructions further and pointed out more strategies on how to get the fires started. The non-Aboriginal students I saw appreciated these gestures of help and together, I noticed how they got consensus on what would be the best strategy. This definitely had a spill over into my classroom, because when I assigned seats for Aboriginal students to sit next to non-Aboriginal students to discuss the theory behind the practical component, they were not as reluctant to do so.

The yarns indicated that embedding Aboriginal perspectives into science lessons had a positive impact on the relationships between Aboriginal and non-Aboriginal students. The curriculum innovation built stronger connections between the students as they communicated respectfully, worked collaboratively and developed meaningful relationships.

Aboriginal Students' Perspectives

Comments made by the Aboriginal students during the yarning sessions indicated that the curriculum innovation lessons fostered better relationships with their non-Aboriginal peers. During the yarns, the Aboriginal students said that they appreciated that the non-Aboriginal students listened to the Aboriginal stories to get a better understanding of them. The Aboriginal students found that the non-Aboriginal students were willing to learn about Aboriginal culture and ways of doing things and they began to find ways to work together more closely. One of the students remarked, “The *wadjella* boys tried their way of doing things and we tried our way, but we also mixed up our ideas to see if we could come up with something new and better to solve the problem” [Student 3]. Another student said:

I knew the stuff so I showed my *wadjella* mates how to throw the spears and boomerangs 'cos we learnt that when we were kids. Also, my Pop plays the didgeridoo so I know a little bit and I tried to show the *wadjella* boys how to play it. [Student 2]

Finally, another student summed up the change in peer attitudes when he said:

I felt good that our culture was not laughed at or made to look silly, but was important in science. Sometimes you get teased and bullied for being Aboriginal, you know you get called names Black this or that, but instead of feeling shame we felt proud to see the White kids learning our stuff and listening to true stories about what really happened to Aboriginal people and how they still remain proud in their culture and scientists today are using Aboriginal knowledge to help save the planet. [Student 7]

Connectedness with Aboriginal Parents and the Community

In this section, the term connectedness is used to describe the sense of belonging and feelings of acceptance that the Aboriginal students, parents and community experienced during the curriculum innovation. Having Aboriginal perspectives included in the science lessons made students feel as if they had as much right to be included in the curriculum and this gave them a sense of pride, dignity and importance. This section describes this feeling of connectedness from both the teacher and the students' perspectives.

Science Teacher's Perspective

The yarns with the science teacher suggested that, for her, there was an increased sense of connectedness with the Aboriginal parents and community. The teacher acknowledged that, prior to the curriculum innovation, she only saw the Aboriginal parents at designated parent meetings, some of which were not well attended. However, when she started to involve the parents and community members to incorporate local Aboriginal knowledge, history and culture into science, she started to establish a closer relationship with them. She recalled various ways in which she achieved this:

When I started this curriculum innovation, I had no clue as to how I would link the science concepts and curriculum to Aboriginal knowledge and culture. The Aboriginal guest presenters joining me in the science classes were a huge benefit as they were a wealth of information and easily connected Aboriginal concepts to science, like the science behind the didgeridoo, fire making, spear throwing, bush medicine etc. But then I also had to take the initiative to find more information myself, so I decided to ask the students to ask their parents and grandparents for help. This help came in abundance and soon we were having parents and grandparents come and teach students how to make damper and kangaroo stew, how to make traditional tools and talk about caring for country. Parents were also

keen to be helpers at the school, especially for NAIDOC week¹⁷, and volunteered their time for art lessons and assisted with NAIDOC activities.

The teacher felt that, by developing a connection with the parents and the local community, she was able to cement genuine relationships with them. She felt confident that this connection would allow her to seek help from them in the future in designing her lessons. She said:

This experience made me feel more comfortable with the Aboriginal parents and I felt less awkward to approach them to ask for help. When we met for Naidoc celebrations or casually in the shopping centres, our conversations were a lot easier and flowed, as we had connected in the classroom; we now seemed on equal shared ground. I felt that the parents and presenters respected me for taking on this challenge and I felt heartened when I heard the reference to me as “deadly.” I was happy to be a deadly science teacher.

The teacher believed that, by opening her classroom doors to parents and community members, she was able to establish effective partnerships with parents to discuss their children’s progress and behaviour. She overheard the Aboriginal students say “now that Miss knows my family, I will get a hiding if I misbehave,” on a number of occasions. She laughed as she recalled this and said that she realised the potential benefits from involving parents and community, as the parents were more comfortable in interacting with her and saw her as someone who was supportive of their children’s culture. Trusting relationships were developed as she spent time talking to and getting to know parents and community members.

She also found that her relationships with the Aboriginal and Islander Education Officers (AIEOs) at the school were strengthened, as she connected with them more often and they became her key link to the parents. She said:

¹⁷ NAIDOC week: a week set aside across Australia to celebrate the history, culture and achievements of Aboriginal and Torres Strait Islander peoples. Organisation was once the responsibility of the National Aborigines and Islanders Day Observance Committee and its acronym has since become the name of the week itself.

I began to really value and appreciate the presence of my AIEOs at the school, and started to use them as valuable resources. They would contact parents for me, support students who were struggling with personal issues, and they too were able to team teach with me, linking Aboriginal content to science principles. They also helped me to understand the nuances of Aboriginal English and interpreted colloquialisms and a lot of Aboriginal expressions and words. In fact, learning to use the Nyoongar words like *deadly* and *solid*¹⁸ got the students more connected to me and the content as the students felt I was on their level.

Aboriginal Students' Perspectives

Throughout the yarns, the Aboriginal students commented that they enjoyed connecting with the Aboriginal guest speakers at their lessons, and involving parents, community members and other Aboriginal people in the lessons. To this end, one student said: “Aboriginal people hold our knowledge, so having them come into our class to teach us Aboriginal ways was better and more interesting. They [Aboriginal people] know so much about their stuff” [Student 2]. Another student commented:

Having our own people come in to teach us things was good. We have never had an Aboriginal teacher in our school, just AIEOs but they are not allowed to teach the whole class. It was good for the Aboriginal presenters to teach everyone so other Aboriginal students can also be encouraged to become science teachers. [Student 7]

Finally, another student said:

Some of the stuff the guest presenter told us was *deadly*; the bit about finding those compounds that stimulate the seeds growing which they told us are called the *karrkins*. We didn't know that it got its name from our Nyoongar word *karrik*, which means ‘smoke’ and man that was discovered here in WA. [Student 1]

¹⁸*Solid*: Aboriginal word meaning fantastic, awesome, good.

Connectedness as a theme was clearly evident during the curriculum innovation lessons, as demonstrated by the yarns with the research participants. The second theme that emerged was the development of enhanced confidence.

Theme 2: Enhanced Confidence

Throughout the curriculum innovation lessons, the Aboriginal students displayed enhanced confidence, as portrayed in the narratives. During lessons observed prior to the curriculum innovation, the Aboriginal students exhibited behaviours that were indicative of low confidence in regard to the curriculum which included shyness, lack of communication, social isolation and lack of eagerness. During the curriculum innovation lessons, however, two aspects of enhanced confidence were observed and were reflected in the abilities and aptitudes of the students, and the leadership skills demonstrated by the Aboriginal students, as discussed below.

Abilities and Aptitudes

The terms abilities and aptitudes are used in this study to describe the knowledge and understanding the students demonstrated during the study as well as their potential to carry out the tasks. This sub-theme (related to students' confidence) is described separately from the teacher's and the students' perspective. It must be noted that the role of the learning environment and pedagogies to enable student competence and strengths is a significant factor. The failure of students to engage in the standard classroom highlights that the students are not lacking aptitude or ability but rather the environment is failing to address their ways of knowing and doing. The responses from both the teacher and students point to a key finding that innovative learning environments and pedagogies have the potential to contribute to improved cognitive, affective and social learning outcomes for students.

Science Teachers' Perspectives

During the yarns with the teacher, it was clear that the changed model of curriculum enabled the students existing abilities and aptitudes to be manifested more positively. Yarns indicated that the teacher was convinced that using Aboriginal perspectives in the science lessons was a strength-based approach to working with

Aboriginal students. By using Aboriginal perspectives, she felt that the Aboriginal students began to experience success at what they were doing. The students, she noted, “were not limited by their previous underperformance that they had experienced in their regular science lessons.” She went on to say:

The Aboriginal students [in my science classes] were at the forefront of the curriculum innovation lessons as proficient and skilled participants. This was so different to how they came across in my normal science classes. I found them to be more proficient in the new lessons; they had more know-how, and were not “shamed” as they so often tell me.

The teacher noted that, for many of the Aboriginal students, the process of learning science and any new concepts was sometimes overwhelming, likening it to “swimming in an ocean and caught between different tides.” She commented that learning science:

Can cause students to feel anxious, uncertain and fearful and sometimes this is why they play up. You know, when we used Aboriginal perspectives the context was there and this built the students’ confidence and gave them a bit of control of their learning and a willingness to try their best.

Aboriginal Students’ Perspectives

The yarns with the students indicated that they, like the teacher, recognised their increased abilities and aptitude and leadership during the curriculum innovation. When they spoke about what they had done and how they performed activities during the curriculum innovation lessons, there was a sense of pride in their voices which expressed clearly that something had changed.

Yarns with the Aboriginal students supported the teacher’s view that embedding Aboriginal perspectives into the curriculum strengthened their confidence. The phrase “I understood everything” came up on numerous occasions. During the yarns, the students shared stories about what they had done in the curriculum innovation

lessons and how much they enjoyed it. One student reflected the thoughts of others when he said:

I wish we could learn like this all the time Miss. That was boss¹⁹... sometimes me and the boys like to wag²⁰ science and go to the footy academy, but when we were learning the Aboriginal culture stuff we just wanted to stay and do stuff and didn't want to leave. [Student 5]

My observations indicated that in the curriculum innovation lessons the students displayed more proficiency than in the regular lessons. Yarns with the students suggested that they too felt this way. One of the students stated:

I didn't have to fake knowing the stuff like in my science class ... cos all that science work was very hard for me and I just copy off my mate when I don't know the answers. When we were learning with the "uncle" I knew the things myself ... like how to make a fire, how to throw spears, how to play the didge. We seen that done by my Pop and he taught us too. [Student 10]

Overwhelmingly, the student yarns indicated that believing in their abilities as they did during the curriculum innovation lessons was empowering, and helped them to raise their self-esteem and self-confidence. For example, one student stated:

Us Aboriginal students always feel shame when we have to speak in front of the class. We don't speak smart like some of the Wadjellas. But it was alright when the Aboriginal presenter asked us to come to the front. We knew what he was talking about so we could answer questions better and didn't have to feel shame. I kinda felt important too because only us Aboriginal kids knew the answers for a change. [Student 5]

Leadership

The term leadership is used to describe the position of authority and management the Aboriginal students took on during the curriculum innovation lessons. Throughout

¹⁹ *Boss*: slang meaning top-notch

²⁰ *Wag*: slang for skipping class

these lessons, the Aboriginal students were observed to adopt positions of influence by sharing knowledge and skills and guiding others during the curriculum innovation lessons. In this section, both the teacher and the students describe how and why the students rose as leaders during the curriculum innovation lessons.

Science Teacher's Perspectives

The curriculum innovation lessons were also viewed by the teacher as a means of promoting the Aboriginal students into positions of leadership. She commented that the “self-doubt” that the Aboriginal students experienced during her regular lessons was absent in the curriculum innovation lessons. Instead, she noted that they “exuded an executive presence as they took on leadership roles.”

The aura of leadership that prevailed during the curriculum innovation lessons was demonstrated in various ways, as explained by the teacher:

I feel the curriculum innovation lessons provided the opportunities for the Aboriginal students to display their leadership skills and they jumped into lead roles of showing and influencing non-Aboriginal students to perform activities like spear and boomerang throwing, playing a didgeridoo and making tools. I feel they were leaders, because they were teaching others and they delegated roles to their peers, supervised activities and mentored them through difficult tasks like getting the fires going. They thus built team spirit and collaborative learning.

Further, the teacher noticed a level of positive assertiveness in the Aboriginal students as they spoke confidently to emphasise their ideas and explanations. They were also less shy to speak in front of the class and initiated ideas for further science lessons that could include Aboriginal ideas. The teacher mentioned an example:

I think as we went on with the curriculum innovation lessons, the students wanted more of this and would come up to me with suggestions as to how other science topics could include Aboriginal ideas. One student told me his Aunty worked at an Aboriginal centre called Marr Mooditj and he could get her to come to the science class and teach them about bush

medicine and how to make products using Aboriginal native plants. I could see that this would fit into our chemistry syllabus for the next term and was proud that my student was showing such leadership.

Opportunities to experience positions of leadership during the curriculum innovation lessons appeared to make the Aboriginal students more dependable and responsible. The teacher described how the Aboriginal students were more responsible:

The Aboriginal students were my main helpers in the curriculum innovation lessons, I'm sure you noticed too how they came in early to help me set up for the lessons. They eagerly ran out to help the guest presenters without any prompting. They took care of the guest presenter's artefacts and did not hesitate to give up their time to look after them.

Further, the teacher noted that the students behaved in a more responsible manner during the curriculum innovation lessons. She explained that during these lessons there was no "fooling around with their peers or fidgeting and being disrespectful. They required less supervision and took responsibility for their own learning."

Aboriginal Students' Perspectives

The feeling of being important and knowing what they were doing was a common thread during the yarns with the Aboriginal students. The students reflected on how they contributed more to the curriculum innovation lessons, and how they felt more responsible for leading many of the activities. A student who sat at the back of the regular science classes and chatted often to his friends said:

I felt I had a responsibility to my culture and my people to do the right thing in the Aboriginal lessons, and I had to lead the way. I couldn't let my people down and it was okay anyways cos it's stuff I know and I could teach it to the class. The Aboriginal presenter knew us fullas too and our family so we had to take our rightful place and show we were leaders.
[Student 11]

The students generally agreed that they were able to use their cultural understandings to connect to the normal science that their teacher taught them. One student said, “I felt less shame and had more words to describe what was happening” [Student 3].

Embedding Aboriginal perspectives in mainstream science lessons appeared to give Aboriginal students a sense of ownership and importance. They expressed that when the teacher drew on their cultural capital during science lessons, they were able to articulate their knowledge more effectively and engage more productively in lessons. A student encapsulated this when he said:

When you saw us in term one, we mucked up quite a bit, but we were bored and sometimes the science stuff gets too hard. But when we looked at the Aboriginal side of things, it got way better and that’s our business, what Blackfullas know. [Student [no. 9]]

Another student said:

It was like our rights, you know our cultural stuff, our customs, traditions, tools, techniques and how we did things. We owned it. The White kids had to listen and learn about how we did things and this made me feel proud and not shame and I didn’t mind standing up and talking in class about stuff I did with my dad and Pop. [Student 2]

During the curriculum innovation lessons, the students felt that the science teacher was not the only voice of authority, but that they also had the opportunity to take ownership of certain activities. They did this with pride, responsibility and commitment, and as summed up by one student:

We were boss. We could plan how we wanted to make our tools, and what shape to make it. Also we got in groups and made our own fire and the teacher wasn’t on our back you know like guarding us. [Student 9]

Theme 3: Promotion of Aboriginal Students' Learning strengths

The third theme that emerged through the yarns with the science teacher and Aboriginal students was that embedding Aboriginal perspectives in science appealed to the Aboriginal students' learning strengths. This resonated throughout the study, as reported below, as revealed by analysis of the yarns with the teacher and yarns with the students.

Learning Strengths

The term learning strengths refers to the way in which students prefer to learn. That is, some students are visual learners, while others may prefer using words and sounds and still, others prefer learning by using their hands and sense of touch (O'Toole, 2014). Some Aboriginal students have been found to have a unique approach to learning, however, although there is some evidence that narrative, co-operative, non-linear and holistic approaches are more inclusive of Aboriginal students it is important to remember that 'Aboriginal learning strengths' can be overgeneralised and can homogenise Aboriginal students – these so called 'learning strengths' are culturally determined rather than innate – and should not be generalised, as discussed in chapter two.

My results indicate that when the curriculum values and encourages them to learn in their own way, their engagement is enhanced. Both the teacher and the students commented on how Aboriginal learning strengths were embraced during the curriculum innovation and how this impacted on their engagement.

Science Teacher's Perspectives

Yarns with the science teacher afforded rich data as to how, during the curriculum innovation, Aboriginal students responded to hands-on learning, storytelling, visual stimuli and modelling of concepts. After the curriculum innovation lessons, the teacher spoke to me about the differences that she noted in the way Aboriginal students learned:

Ever since I have been involved in this trial, my observations of the Aboriginal students and how they were engaging in my lessons became

deliberate. After spending time with the Aboriginal guest presenters and seeing how they presented their content it began to dawn on me that formal learning was not the priority and that getting concepts across the way that I do in my regular science lessons was very different. In my lesson planning, I have always made sure that it was structured with a definite starting, beginning and end. When I observed how the guest speaker embedded Aboriginal perspectives in science I noticed a more circular organisation if you can picture that. You know, things went around.

The science teacher elaborated on some of the learning strengths that were used during the curriculum innovation lessons that appealed to Aboriginal students. She spoke of how, when she was involved in the curriculum innovation lessons with the guest presenters, the teaching and learning approaches were more narrative based, and the students learned by listening to stories that appealed to the students:

Even though the students were learning about science a lot, the lessons involved storytelling and the Aboriginal students enjoyed this learning style. I think copious reading from text books and complex vocabulary sometimes throws the students off, too much paper and pen stuff they would say. But with the storytelling, they were attentive, and I knew they were listening because they answered the questions correctly and, when they went off to carry out a task, it was obvious they had absorbed the information because they were able to follow the instructions.

She also remarked that:

Whenever there were visual stimuli and images the Aboriginal students remembered what they had seen. This was also true for diagrams and pictures ... you know ... when I used them they seemed to have an overall view of what they needed to do. They liked the use of colour, especially when I incorporated the Aboriginal colours of black, red and yellow ... they would say, “that’s deadly colours Miss.” They also responded well to symbols and metaphors from stories. They actually explained to me some of the metaphors used in the Dreaming stories, like the emu in the sky,

how the Kangaroo got its pouch, and were fond of saying “we talk in round about ways.”

The teacher said that this visual learning style extended into the outdoor activities, where students enjoyed observing and experiencing activities.

The teacher said that “this practical way of doing things appealed to students and particularly so when they were outside the confines of the classroom.” The teacher smiled when she commented:

The Aboriginal students loved getting out of the class and never shied away from doing things such as the fire making, tool making, didge [didgeridoo] playing, spear throwing and the activities with Sci Tech. They just jumped at any opportunity to be involved with practical hands-on things. They [students] could be out on the oval for hours having a yarn, making things or trying out activities without getting bored. The curriculum innovation lessons provided them with opportunities to get outside and this encouraged them to use their senses of sight, smell and touch to make their observations. For example, with the fire making they could see the smoke, smell it and feel the heat. This made me realise that Aboriginal students enjoy learning outdoors.

The teacher also noted that the strategy of modelling appealed to Aboriginal students, which involved “showing students what they should do by doing it myself.” She found that the Aboriginal guest presenters did this most of the time, showing the students what to do first, and then getting them to imitate the actions.

The Aboriginal students, she said, “responded positively and prompted students as they already had an example that they could build on when they felt stuck and couldn’t think of anything else.” Task and performance modelling occurred quite frequently during the curriculum innovation lessons, as the Aboriginal guest presenters preceded activities such as fire making, didgeridoo playing and tool making with active demonstrations. All students were able to observe first what was expected of them.

Similarly, learning by sharing and working in a team was preferred by the Aboriginal students. The teacher commented that:

The Aboriginal students enjoyed the curriculum innovation science lessons, working in groups, cooperating with each other on the oval Making tools together and then using them was quite fulfilling for the students and they always asked for more of these kinds of activities.

Aboriginal Students' Perspectives

Yarns with the students about how they learn best pointed to distinct learning strengths that they responded to during the curriculum innovation lessons. The students said that they preferred hands-on learning, storytelling, receiving visual stimuli and learning from others.

Throughout the yarning session, the Aboriginal students indicated that the curriculum innovation lessons appealed to their learning strengths. The phrases “hands-on” and “I like doing things” were often heard during the yarning sessions. One student put it eloquently when he said:

I personally think that science should be much more hands-on to interest Aboriginal students. I mean seriously how boring is science when you just sit there doing calculations about this that and the other and writing down things that you don't really understand because you haven't really seen it in action. What would attract me to science is the practical hands-on things that let you discover and learn. [Student 1]

The students were unanimous in their desire for a hands-on curriculum in science. All of them mentioned that they did not like it when their teacher relied solely on the use of textbooks and worksheets, saying that it became boring when she only talked and wrote on the whiteboard. One student commented:

We're always watching things and we can learn from watching others. We can easily do what someone shows us by practising it. Like the tool

making; I made my own axe and no one taught me that before, but I learnt on the day and now I can make one on my own. [Student 7]

Yarns with the students confirmed what the teacher had said, that visual stimuli appealed to them, as well as stories, music and dance. Students listened attentively to the guest presenter who told them stories about the various tools that were used by Aboriginal people.

Throughout the yarning sessions, the students expressed that they enjoyed how the guest presenters “brought ‘stuff’” into the classroom to teach them. They were referring to the Aboriginal artefacts that the Aboriginal guest presenters used to illustrate what they were talking about. As mentioned by the teacher earlier, using visual stimuli appealed to and engaged the Aboriginal students. All of the students agreed that the science activities based on touch, sight, sound and taste were enjoyable. One student summed it up by saying:

The pictures that my teacher used when we were learning about mineral resources and how the land is being used in Australia helped us to have an idea because we haven't seen that before. We also learnt about some of the animals and plants from the photographs and seeing the soil too, you know you can tell which kind of Aboriginal place that it is from the soil; if it's desert, and you can judge the weather and how the water will be there. [Student 6]

Another student commented that:

When the Aboriginal presenter told us about how Aboriginal people made cooling fires, he showed us pictures of the different trees and we saw a Boab tree and then we started talking about that because we saw the GijaJumula tree in Kings Park and how they brought it from the Kimberley. It was huge and then we looked at Boab trees in Africa and Madagascar and no one still knows for sure how the Boab tree came here from Africa. [Student 9].

According to the students, using visual stimuli when embedding Aboriginal perspectives developed students' thoughts around topics, and helped them to remember and develop and explore further ideas. Using local Nyoongar resources in the science lessons for demonstrations made learning more interesting and enjoyable for the students. One student commented, "It was boss²¹ to see the artefacts and deadly that we could use them, like the cloak, spears, boomerangs, tools and didgeridoos" [Student 11]. Of the teaching styles used during the curriculum innovation lessons, one student said:

I enjoyed the storytelling about how Aboriginal people used science and about the Dreamtime creation stories of the Rainbow Serpent who created the waterways and land. It was interesting, to hear about the animals and why they do certain things. My Pop also told me those stories, like why the kookaburra laughs like that, you know so loud, and the story of the wagtail, which we call the *djittidjitti*, and why magpies and crows hate each other. [Student 17]

Gaining information through Aboriginal storytelling appealed to the Aboriginal students and, as one student said, "It's the way we were raised; our families always tell stories and yarns."

Students also enjoyed working with their peers to experiment and discover how scientific principles worked. As one of the students commented, "Experimenting is the best thing about science instead of learning from the text book. At least we can see for ourselves what is happening. It is not boring and we get to do and make cool stuff."

Another student commented:

It was nice in the Aboriginal lessons, 'cos we didn't have to memorise stuff for tests and copy lots of notes and do so many worksheets. We were able to work in groups on projects. [Student 17]

²¹ Boss: Colloquial term meaning good or important.

Learning beyond the physical classroom with their mates was also preferred by the student. As one student said:

It's just the best being out in the oval with your mates, instead of the stuffy class. Its fresh air and that's why we like footy 'cos we can be outdoors. So when we were doing science outside it was good and we didn't have to stare at the teacher or look at the whiteboard all the time. It was better to learn out there with our friends. [Student 1]

Theme 4: Changing Perceptions of Science

The fourth theme that emerged during my yarns with the research participants was that, by embedding Aboriginal perspectives in science, some negative perceptions of science perceptions were successfully changed. This theme draws on the three preceding themes, as perceptions about science were challenged by fostering connectedness and by students experiencing more confidence in science through learning strengths that appealed to them. In this section, yarns with the science teacher and the students are used to examine how perceptions about science changed when Aboriginal perspectives were included in the science lessons.

Science Teacher's Perspectives

During her regular science lessons, the teacher commented that “the students were not really interested in science, and would often comment, “Miss this is too hard,” or “this is too boring,” or “I'm not going to do science after Year 9.” During the curriculum innovation lessons, however, the teacher noted that many of the perceptions students held about science being too hard and boring were replaced with more positive responses from the Aboriginal students. She attributed this to the inclusion of Aboriginal perspectives:

Aboriginal perspectives really influenced the way the Aboriginal students saw science and, as a result, they demonstrated more positive emotions towards it. I think a lot had to do with the more affective domain. You know, appealing to students via their feelings about something and not just concentrating only on the learning of concepts. We included a lot more

topics about the value of things; we talked about stereotypes and attitudes and why people are motivated to do things they do.

By decentralising the focus on just science learning, the teacher felt that the curriculum innovation lessons helped to change the students' perceptions that science was uninteresting and boring. The more holistic approach adopted during the curriculum innovation lessons changed their perceptions. The teacher commented:

I feel that the deliberate attempts made to teach science differently, you know by adding Aboriginal perspectives, influenced students' perceptions of science, and it kind of demystified science for them a bit. The more experiential style of learning drew them in and so they were not bored. Also the more hands-on learning and learning outside the classroom also helped to make science more practical and interesting for the students.

Introducing Aboriginal content and Aboriginal learning strengths, and showcasing the successes experienced by Aboriginal people in science, facilitated more positive reactions from Aboriginal students. The teacher reflected that:

The Aboriginal science, from what we included to how we taught the students, made a difference. They were more curious and interested. They hadn't known about all of the Aboriginal inventions and the many Aboriginal scientists that were out there. We did a section on Aboriginal health science professionals and this was an eye-opener to students. It gave them a chance to see how many doctors there were in Australia, and what was very influential was the fact that some of these doctors had come from similar backgrounds to theirs. A lot of them had been affected by poverty, the stolen generation and other emotional problems, but they still succeeded. I knew students were moved by this because they asked me to make copies of these stories for them to take home. Normally they just rush out [of class], but asking for copies and waiting for them instead of rushing out made me believe that there was a genuine interest. They also started asking questions about entry requirements for science careers, saying "Miss what subjects I have to study to become a doctor? How many

years does it take to be an engineer? Do I need to study physics? Are physiotherapists doctors?”

The shift in focus to Aboriginal perspectives in science appeared to create a space for Aboriginal science and scientists to be showcased. The teacher felt that Aboriginal students were able to reassess the previously-held perception that science was too hard, boring and difficult for Aboriginal students to get into.

Aboriginal Students’ Perspectives

During the very first yarn with the Aboriginal students, we talked about scientists and what they thought a scientist did and looked like. The students held views of scientists as predominantly male, wearing glasses, with crazy or no hair and wearing lab coats. The students struggled to identify anything fun and appealing about being a scientist, nor could they name anyone in their families who had studied a science degree at university.

It would appear that, during the curriculum innovation lessons, some of the scientist stereotypes were dispelled. Some of the students described how the curriculum innovation lessons promoted this:

Well most of us thought scientists were really geeky and nerdy types. Like book smart ones who don’t go out but just study all the time. But when we learnt about Aboriginal scientist David Unaipon, it changed our mind. Some of the students didn’t even know that he was on the \$50 note, but it inspired us because he left school when he was 13, but was so smart to invent things and he was thinking about how to make a helicopter long before White people did. I thought wow, if he could have dreamed of doing stuff like this so many years ago we can also try and we have more technology now. So yeah, that was a good way to get us interested in science. [Student 11]

Another student said:

I always thought I could only try for humanities subjects like SOSE because that's the courses Aboriginals [sic] have more success in. How many Aboriginal students do you hear about with high grades in science? But the presenter told us about many Aboriginal scientists and this helped us realise that we may be narrow in our thinking, but teachers have to tell Aboriginal kids about this. Even our parents don't tell us about science and how good it is, but they don't have the information too and they don't have computers and not many finished year 12 even. [Student 22]

The Aboriginal girls too said that, before the curriculum innovation lessons, they hadn't heard of any Aboriginal girls who had achieved in science or science careers. One student commented that:

We always think science is not for girls, most of us choose cooking as a subject and many Aboriginal girls are *boodjarri*²² really young and don't go to university. They just become young mums. But it was interesting to hear about the first Aboriginal doctor. And she was a female so this made us feel proud that it was a girl who made it first. It kinda encouraged us not to think small and to try and dream big and maybe more girls can become doctors and scientists and engineers. [Student 6]

Another girl suggested:

Maybe girls need to get more information about *yorgas*²³ doing science stuff. Like in these lessons, we learnt about other *yorgas* who studied science. If they could do it, maybe it's not that hard and boring and we could also have a go. [Student 5]

The girls were unanimous in their view that their perception of science was that it was not feminine and that more boys studied it. They also thought that they would need to be super intelligent to study science. One girl laughed and said:

²² *Boodjarri*: Aboriginal word meaning pregnant

²³ *Yorgas*: Aboriginal word for girls

I think everyone thinks girls cry too much and are too emotional and get all eeky²⁴ when there is blood and stuff. So we have to get over that. Not all girls are like this and some are very brave to become doctors and engineers. [Student 16]

During the curriculum innovation lessons, the students were better informed and exposed to science. One student reflected:

We don't really have correct information about science and scientists. We just keep thinking they're *winyarn*²⁵ and science is so hard. But during the lessons with the Aboriginal presenter, we learnt about some exciting careers in science. Like we could become environmental scientists and use Aboriginal technology and work for CSIRO or CALM. We could become park rangers and they also use science. We could study the stars and work at the observatory. There were so many jobs on the list he showed us. [Student 16]

The curriculum innovation lessons certainly went a long way in demystifying science and reducing the negative stereotypes of science and scientists. They also helped to minimise the low expectations that students had of their ability and boosted their confidence and self-belief. They encouraged students not to be disillusioned by low expectations held by others. The following chapter provides a discussion of these findings and those of the other research questions.

²⁴*Eeky*: An expression meaning to be frightened

²⁵*Winyarn*: Aboriginal word meaning not good.

Chapter 7

Discussion and Conclusion

In this chapter, I critically examine and discuss my findings as I summarise the original research questions which formed this study. I also endeavour to seat my findings in the wider field to provide further understanding of the localised perspective. Included in this chapter is: a reconsideration of the research questions; an example of an application of the findings; an outline of the limitations of the research; and an overview of the limitations and significance of the research.

Reconsidering the Research Questions: My Reflections

As I reconsidered my research questions, I found myself reflecting on the extraordinary opportunity that I have been afforded. This opportunity has allowed me to look into possible reasons as to why some Aboriginal students have been disengaged from science and how this might be overcome. In examining how I established my questions, I found myself reflecting on my PhD journey which, admittedly, was overwhelming at times. As I write this chapter, I acknowledge that I could not have entered this area of research if it were not for the Aboriginal community with whom I have been working with on a daily basis over the past twelve years. I have been welcomed to walk in their Country, to listen to their voices and to learn about their culture and heritage. I have grown to love the old Aboriginal proverb which reminds us that “We are all visitors to this time, this place. We are just passing through. Our purpose here is to observe, to learn, to grow, to love and then we return home” (O’Neill & Zinga, 2008, p. 100).

My journey began some 14 years ago, when, during my work with Aboriginal students, I identified what I called science aversion in the students enrolled in my program. Over the years I have noticed that students were unlikely to enrol in science subjects, as they considered them to be too difficult. What stood out for me was the way in which these Aboriginal students changed when they were situated in their cultural setting. By this, I mean that they would become more animated and excited when the activity involved Aboriginal culture or Aboriginal people. This was the pin-

dropping moment; when I realised that the inclusion of traditional Aboriginal cultural practices had a positive effect on the students and that this may be the approach needed to engage Aboriginal students more effectively. Gathering the views of Aboriginal Elders in my local community and reviewing the literature affirmed what I had thought and observed.

My study, therefore, was a small attempt to examine whether the approach of embedding Aboriginal perspectives in science could be successful with Australian Aboriginal middle school students of Nyoongar descent. Trialling the innovation was challenging yet exciting at the same time. I spent six months at a local school where, for the first three months, I observed the engagement of Year Nine Aboriginal students in their regular curriculum. In the next three months, I observed the engagement of the same students when the curriculum was integrated with Aboriginal cultural perspectives. I was overwhelmed by the difference in the behaviour, attitudes and engagement of the Aboriginal students during the innovation lessons when compared to their engagement in the regular science lessons. It seemed that the students had come alive in their own cultural milieu.

There were two main research questions that guided my investigation:

1. What are the observable differences in the engagement of Aboriginal students when they are involved in Western science lessons and lessons that are embedded with Aboriginal perspectives?
2. What are the possible reasons for the increased engagement of Aboriginal students in science when Aboriginal perspectives are embedded into a prescribed school science subject?

In this chapter, I summarise the results for each of the research questions. I then discuss the findings in terms of the literature and offer an evaluation of the importance of these findings. Finally, I look at possible directions for future research in this field.

Student Engagement: Embedding Aboriginal Perspectives in Science Lessons

This section summarises and discusses the findings related to the first research question:

What are the observable differences in the engagement of Aboriginal students when they are involved in Western science lessons and lessons that are embedded with Aboriginal perspectives?

For Australian Aboriginal students, science is a complex and often difficult subject. It would appear that the complexities and challenges associated with engaging in science is heightened for these students, possibly due to the Western discourse embedded within a subject, which frequently does not take into consideration Aboriginal ways of knowing, doing and being. These problems became apparent during my observations in regular science lessons (discussed in detail in Chapter 5), during which Aboriginal students were disengaged, as evidenced by their behaviours. Some of these behaviour patterns included: teasing other students; attention seeking; difficulty following routines and rules; difficulty controlling impulses and managing their own behaviour; difficulty staying on task and completing tasks; and becoming easily frustrated with science tasks or requirements. The emotional and behavioural engagement of the Aboriginal students demanded that the teacher implement a range of behaviour management strategies to maintain order.

During the innovation lessons (when Aboriginal perspectives were embedded within the science lessons) a different picture emerged. During these lessons, Aboriginal students were observed to be more responsible for their learning, displayed enhanced self-confidence, and demonstrated more cooperative working habits. Additionally, they were observed to be more self-disciplined, hardworking and dependable during the innovation lessons. Overall, the Aboriginal students were observed to behave in a more mature manner and were more enthusiastic and motivated than in the lessons observed prior to the innovation. These findings reflect much past research that has involved the embedding of cultural perspectives that was carried out internationally (Aikenhead, 1997, 1998, 2000a, 2000b; Michie, Anlezark & Uibo, 1998; Michie & Linkson, 1999, 2000; Valenzuela, 1999). The findings of these studies indicate that

including and valuing students' culture is likely to lead to improved outcomes, including academic performance (Demmert, 2001), situated cognition and engagement (Aikenhead, 1996; Cobern, 1993), and confidence and pride (Holm & Holm, 1995; McCarty, 1993). Conversely, studies also found that when students' language and culture were ignored, this led to poor self-concept and low self-esteem, resulting in behavioural and discipline problems (Valenzuela, 1999).

The improved emotional and behavioural engagement of the research participants provides strong support for embedding of Aboriginal perspectives in high school science classes. Given the observable difference in student behaviour and engagement, it is recommended that embedding Aboriginal perspectives into high school science can be used as a means to turning around the current disengagement that many Aboriginal students experience in science (Recommendation 1).

Reasons for Improved Engagement

This section summarises and discusses the findings related to the second research question:

What are the possible reasons for the increased engagement of Aboriginal students in science when Aboriginal perspectives are embedded into a prescribed school science subject?

My results suggested that embedding Aboriginal perspectives into science lessons led to improved behaviour and engagement of the research participants. In exploring possible reasons for this improvement, the results indicate that embedding Aboriginal perspectives: 1) fostered connectedness; 2) highlighted Aboriginal students' confidence; 3) appealed to Aboriginal students' learning strengths; and 4) changed the Aboriginal students' perceptions about learning science. Each of these are discussed below.

Theme 1: Embedding Aboriginal Perspectives Fostered Connectedness

This results of this study indicate that Aboriginal students are more likely to engage with Western science when they feel connected to and included in the curriculum. Connectedness as a construct relates to the contextual and relationally oriented social-ecological view of development which emphasises that social relationships and interactions that occur between individuals, schools, families and communities enhance students' engagement with their schooling (Bronfenbrenner, 1989). Roffey (2008, p. 29) notes that "connectedness encompasses how students feel at school, their participation and engagement with learning, and the quality of the relationships they experience."

In my study, I found that including experiences that were familiar and relevant to the Aboriginal students in science lessons fostered: connectedness with the curriculum; connectedness between Aboriginal and non-Aboriginal students; and connectedness with the Aboriginal parents and community. Connectedness was clearly visible during my observations of lessons during the innovation and was elaborated upon by the students during the yarning sessions (described in detail in Chapter 6). Connectedness was found to be enhanced in a number of areas, including: students' connectedness to the curriculum; the connectedness between the teacher and the students and between students; and the connectedness between the teacher and members of the Aboriginal community.

Connectedness to the Science Curriculum

A key finding of this study is that, in lessons that embedded Aboriginal perspectives, Aboriginal students were more engaged and exhibited fewer behavioural problems. It would appear that, when the science pedagogy affirmed the Aboriginal ways of knowing, being and doing, the students felt that the learning was more relevant and was about them and their culture. As a result, they were more likely to respect what they were learning.

My finding that the incorporation of Aboriginal perspectives fosters connectedness to the science curriculum corroborates much past research that has sought to overcome the disconnectedness that students experience. These studies have also found that

when ethnically diverse students are taught through their own experiential and cultural filters, their engagement improves (Jolliffe, 2015; Pirbhai-Illich, 2011; Gay, 2010; Sharan, 2015). Further, the findings of studies by Lipka (2002) and Joliffe (2015), indicate that student engagement is positively affected when teachers align their instructional practices with their students' culture.

With culture being at the core of identity and defining who Aboriginal people are, how they think, how they communicate and what they value, it makes sense that the science curriculum should use this as building blocks to provide the connection that Aboriginal students need and, thereby, engage them more effectively. Much past research suggests that irrelevant science content and limited opportunities to pursue areas of interest in science classes is hampering the success of students in Australia (Goodrum, Hackling, & Rennie, 2001; Lyons, 2006a, 2006b; Osborne & Collins, 2001; Tytler, 2007). Further, the findings of past Australian studies suggest that one of the key factors to successful engagement for Aboriginal students is the embedding of Aboriginal perspectives in the curriculum (Castagno & Jones Brayboy, 2008; Demmert, 2001; Munns, O'Rourke, & Bodkin-Andrews, 2013). Given the findings of my research (and that of much past research), it is recommended that, to improve the engagement of Aboriginal students in science, educators consider the importance of employing Aboriginal students' cultural background in the teaching of science (Recommendation 2).

The results of my study indicate that creating a suitable learning environment for Aboriginal students requires a cultural context which supports meaningful experiences, encourages engagement and promotes social growth. These findings support those of studies that have been carried out in countries around the world including Canada (Aikenhead, 2005; Snively & Corsiglia, 2000; Corson, 1999; Holm & Holm, 1995; McCarty & Watahomigie, 1998), New Zealand (McConney, et al 2011); and Africa (Le Grange, 2004, Masoga, 2005; Mosimege, 2004; Shiza, 2005). Further, studies by Demmert and Towner (2003) and Kana'iaupuni and Ishibashi (2003) have reported that Aboriginal perspectives enables students to connect more effectively with the science curriculum. My study builds on and extends these studies

by examining the effect of Aboriginal perspectives in science on the engagement of students from the Nyoongar community.

Connectedness between the Teacher and the Aboriginal Students

Another finding of my study is that the connectedness between the teacher and the Aboriginal students increased. This connection was found to contribute to the improved engagement of Aboriginal students during the innovation lessons. My findings indicate that the relationship between the teacher and the students flourished, bringing with it a change in the Aboriginal students' view of the teacher. The findings indicate that the students clearly valued the teacher's efforts in trying to include their culture and using more culturally appropriate learning strengths in the science lessons.

Teachers play a significant role in the education of students and their teaching is a major source of variance in students' engagement (Hattie, 2009, 2012). However, evidence suggests that non-Aboriginal teachers in Australia, despite their best intentions, have inadequate understandings and pedagogies for how to teach Aboriginal students (Aikman & King, 2012; Jones Brayboy & Maughan, 2009; Fredericks, Mann, Skinner, CroftWarcon, McFarlane, & Creamer, 2015; Madden 2015). Therefore, calls have gone out specifically to teachers working with Aboriginal students to connect to their students, to help to positively impact on Aboriginal students' experiences at school (Bodkin-Andrews, Harwood, McMahon & Priestly, 2013; Carlson, 2016; Harwood, McMahon, O'Shea, Bodkin-Andrews & Priestly, 2015; Craven et al., 2005; Lawson & Lawson, 2013; Munns 2013; Hamre & Pianta, 2001; Murray & Greenburg, 2000; McNeely, Nonnemaker & Blum, 2002). My findings support this call, and it is recommended that policy makers and government officials look closely at how teachers can be helped to make these positive connections (see Recommendation 3).

My findings indicate that the connection between the teacher and the Aboriginal students was facilitated by the teacher being more open, respectful and accepting of Aboriginal culture into her lessons, and making a concerted effort to get to know the Aboriginal students on a personal level. My findings corroborate past research that

suggests that embedding Aboriginal perspectives improves teacher student relationships (Burgess & Cavanagh, 2012; Lewthwaite et al., 2015; Hynds, Hindle, Savage, Penetito & Sleeter, 2016; Owens, 2015; Perso & Hayward, 2015). A constant factor in all of these studies was the importance of teachers' connecting to the local context of the Aboriginal students and taking the time and effort to build authentic relationships with the Aboriginal students. With such strong support to suggest that embedding Aboriginal perspectives into the curriculum is likely to forge a closer relationship between the students and teachers, it is recommended that teachers are provided with the means to become more culturally competent so that they are better able to effectively connect with their Aboriginal students (Recommendation 4). This recommendation lends support for the Australian professional standards for teachers, as described by the Australian Institute for Teaching and School Leadership (AITSL, 2015), which requires that all teachers gain the necessary skills to become culturally competent to work with Aboriginal students and teach in a culturally appropriate way.

Connectedness between the Teacher and the Aboriginal Community

A further finding was the notion of a connected community. The findings indicate that embedding Aboriginal perspectives into the curriculum developed a connection between the teacher and the Aboriginal parents and community. The findings suggest that as the teacher collaborated with Aboriginal Elders and community members by inviting them into her classroom as team teachers, her relationships with members of the community strengthened.

Throughout the lead up to and the implementation of the innovation lessons, the teacher looked to the community for cultural protocols, support and resources. The steps that the teacher took to establish and build these personal relationships within the community would appear to be key elements that increased the engagement of the Aboriginal students in science. The Aboriginal students reported that the collaboration between the teacher and members of the Aboriginal community made them feel that the teacher was making an effort to connect to their families and made the curriculum more relevant and personally rewarding to them. These findings corroborate those of other past studies that have reported the potential for Aboriginal

community members to impact positively on the engagement of Aboriginal students (Bryk & Schneider, 2002; Cooper, 2012; Demmert, 2001; Henderson & Mapp, 2002; Hanley & Noblit, 2009; McIntosh, Moniz, Craft, Golby, & Steinwand-Deschambeault, 2014; Trumbull, Rothstein-Fisch, Greenfield & Quiroz, 2001).

My findings corroborate an important principle in Aboriginal education: the building of trust and partnerships with Aboriginal families and the local Aboriginal community. This provides a bridge between the curriculum and knowledge taught at home and, as found in my study, it can be utilised to successfully engage Aboriginal students in their learning. Therefore it is recommended that teachers find ways to reach out and include the community wherever possible (Recommendation 5).

Connectedness between the Aboriginal Students and their Non-Aboriginal Peers

In my study, embedding Aboriginal perspectives had many positive outcomes in connecting the Aboriginal and non-Aboriginal students. My study adds weight to past studies that have found that embedding of Aboriginal perspectives supports the process of reconciliation between Aboriginal and non-Aboriginal Australians (Dakich, Watt & Hooley, 2016; Mooney & Moore, 2013; Mooney, Seaton, Kaur, Marsh & Yeung, 2016; Price, 2012; Peterson & Tudball, 2016). Further, my finding supports those of past studies that found that embedding Aboriginal perspectives may lead to attitudinal change that produces a more cohesive community (Keech, 2010; Kingsley, Townsend, Henderson-Wilson & Bolam, 2013; Mellor & Corrigan, 2004; Phillips & Lampert, 2005; Nakata, Nakata, Keech & Bolt, 2012; Sarra, 2011a, b). It is recommended, therefore, that embedding of Aboriginal perspectives in Australian schools be used to improve communication, awareness and acknowledgement, thereby improving understanding (Recommendation 6).

Theme 2: Strengthened Confidence of Aboriginal students

The second theme that emerged was the improved sense of confidence displayed by the Aboriginal students. Confidence, as a construct, is viewed as how assured students feel about their abilities (Alderman, 2013; McClelland, Atkinson, Clark, & Lowell, 1953). According to Harrison (2011, p. 54), for Aboriginal students, their behaviour in educational settings may be influenced by their motivation to avoid

failure rather than seek success, and to dodge embarrassment caused by making a mistake in front of a group of people, often referred to as avoiding shame.

My findings with respect to the pre-innovation lessons indicate that Aboriginal students presented with observable examples of low confidence (see Chapter 5). This finding corroborates past research that has suggested that a large proportion of Aboriginal students (both male and female) demonstrate low self-confidence in undertaking science as a course of study (Thomson, 2006).

During the science lessons that embedded Aboriginal perspectives, however, the students were observed to listen more carefully, follow directions more effectively, ask for more responsibility and leadership roles, participate in class discussions more frequently, and express their ideas more clearly. These findings indicated a shift in students' attitudes from one of "I don't know," to an "I know how" stance. This know-how stance was demonstrated during the lessons, when Aboriginal students: explained Aboriginal astrology and the concepts of seasons, time and weather from an Aboriginal perspective; provided reasons for the sound produced by a didgeridoo; explained the relevance of the wind when examining the speed and flight pattern of a boomerang; explained how Aboriginal games operated on the scientific premise of push or pull forces; and explained how specific plants were used by Aboriginal people for medicinal and dietary needs.

My finding that embedding Aboriginal perspectives in science lessons led to improved confidence for Aboriginal students supports numerous international studies (see for example Aikenhead, 2000a, 2000b; Gondwe & Longnecker, 2015; Herman, Vizina, & Sawyer, 2008; McKinley & Gan, 2014; Medina-Jerez, 2008; Middleton, Dupuis & Tang, 2013). Given that past research suggests that Aboriginal students have lower self-efficacy (DeBortoli & Cresswell, 2004), and are apprehensive about demonstrating failure and lack self-confidence (Harrison, 2011, p. 54), my finding provides a window into how this might be turned around. In the light of these findings, it is recommended that educators consider strengthening Aboriginal students' confidence through the process of embedding Aboriginal perspectives (Recommendation 7).

Theme 3: Appeal to Aboriginal Students' Learning Strengths

The observations of regular science lessons indicate that the Aboriginal students were not attuned to the lessons, and displayed a lack of attention and disruptive behaviour. The innovation lessons were delivered using traditional Aboriginal teaching methodologies and included experiential learning, storytelling, observation, hands-on activities, modelling, outdoor activities and visual stimuli. The findings indicate that the use of these learning strengths appealed to the Aboriginal students and helped them to engage more successfully in science.

Further, yarns with Aboriginal students indicated that they had a strong preference for traditional learning strengths, and the use of these encouraged their engagement and enjoyment of science. This finding supports those of Hanlen (2010).

My findings corroborate those of other studies that have found that using an appropriate pedagogical model will help to engage Aboriginal students with science learning (Hackling, Byrne, Gower, & Anderson, 2015; Yunkaporta & McGinty, 2009). Past studies that have applied pedagogical approaches such as the ones used during the innovation lessons (including relationship-building, hands-on activity work, participation in classroom discourse, and connecting the science activities to the students' experiences and local contexts) all experienced similar success. Examples of these include the Aboriginal Education Programme (Hackling, Burne, Gower & Anderson, 2015) and the Primary Connections Indigenous perspectives framework (Bull, 2008). Given these findings and those of others, it is recommended that science lessons that embed Aboriginal perspectives consider carefully the learning strengths that they use to ensure that they appeal to Aboriginal students and promote their engagement (Recommendation 8).

Theme 4: Changing Students' Perceptions of Science

An important aspect of this study was to investigate why Aboriginal students were not engaging in science. The findings indicate that many of the Aboriginal students held strong beliefs about science. These beliefs included the view that science was too difficult, boring, and a subject that was only suited to "smart kids." Students also

held perceptions of scientists as old, White men, often balding, wearing glasses and a white lab coat.

These stereotypes are not uncommon in Australian society, as indicated by the stories of three young Aboriginal students whose potential was undermined by their teachers: Josh Harmer (one of Australia's most sought-after paramedic science graduates), Kris Rallah-Baker (Australia's first Aboriginal eye doctor) and Kelvin Kong (Australia's first Aboriginal surgeon). In all three cases, educators gave them the impression that they were not able to succeed, with Kelvin being encouraged to leave school at the end of year 10 (Lawson, Armstrong, Van Der Weyden, 2007).

My findings indicate that embedding Aboriginal perspectives into science lessons may hold the key to removing some of these stereotypes. During the lessons that embedded Aboriginal perspectives, students were provided with insights into Aboriginal science and given the opportunity to learn about Aboriginal scientists. This gave them a more authentic view of science that was couched in a historical, social and cultural context. Through this process, students became more cognisant of the many science-related professions that Aboriginal people hold, such as doctors, dentists, physiotherapists, surgeons, chemists and engineers. As a result, the Aboriginal students began to view science and their ability to pursue science-related careers differently.

This change in perception of their ability to participate in science degrees became apparent when the Aboriginal students questioned guest presenters about entry requirements (for example, what was needed to become an environmental scientist), asked for promotional material about science careers, and were willing to engage in a science camps and programs at universities (designed to break the stereotype that Aboriginal students cannot do science). My findings corroborate numerous international studies that have also reported changes to students' perceptions of science once Aboriginal perspectives are embedded (Agbo, 2004; Abrams, Taylor & Guo, 2013; Apthorp, D'Amato, & Richardson, 2002; Cleary & Peacock, 1998; Demmert, 2001; Demmert & Towner, 2003; Gondwe & Longnecker, 2015; Kao,

Lin, Su & Chan, 2016; Klump & McNeir, 2005; Trujillo, Viri, & Figueira, 2002; Sajidan, Ashadi & Sutikno, 2015; Woods-McConnery, 2013).

Embedding Aboriginal Perspectives in Science: A Guide for Teachers

The results of my study indicate that there were many benefits to embedding Aboriginal perspectives into science lessons which can be beneficial to science teachers. The challenge for non-Aboriginal teachers is to work out ways to use the unique traditions and experiential knowledge (applied by Aboriginal people through their own science for centuries) to science lessons. This section offers a possible map that non-Aboriginal teachers can use to help them to embed Aboriginal perspectives and include the cultural values that Aboriginal students bring into the science classroom. The map aims to be simple and flexible and was developed through consultation with the Aboriginal Consultative Group. It is hoped that it can offer guidelines that are useful to teachers.

These guidelines are the common principles that worked for my particular research group and can be found in Appendix H. As I worked predominantly within the Nyoongar community of Perth, with some students having ties with other cultural groups, it should be noted that these may need to be adapted to suit other cultural groups. Given the diversity of cultural groups, each with varying traditions and protocols, it is highly recommended that consultation with the local community is at the forefront of any attempt to embed Aboriginal perspectives into science lessons (Recommendation 9).

Limitations

It is anticipated that, as with any research, there will be limitations. In my study, these include sample size, sample representation and time frames. Each of these are outlined below.

First, the study was limited by its sample size of 25 Aboriginal students and one science teacher who participated in the study. Given the time restraints of this PhD it was not possible to include a larger sample. It should be noted, however, that the number of Aboriginal students in each class was generally representative of the

number of Aboriginal students in classes in this region. Further, this small sample size allowed much in-depth data to be gathered, yielding rich insights. Given the small sample, however, the results should be generalised with caution. It is recommended, therefore, that future studies include other Aboriginal cultural groups and adapt the cultural content to suit their particular traditions and knowledge (Recommendation 10).

Second, the research participants represented a narrow range of cultural background; that is, my sample belonged predominantly to the Nyoongar cultural group. Given that there are over 600 Aboriginal cultural groups in Australia and each has their own nuances, languages and history, a larger sample with more diversity would have benefited the results and made the findings more generalisable across different Aboriginal groups. It is recommended, therefore, that future studies take this into consideration and try to include a more diverse group of research participants from a range of different cultural groups (Recommendation 11).

Third, it is acknowledged that, although the scope of a PhD did not permit me to spend more time collecting data, this would have strengthened the study. It is recommended, therefore, that future studies include a longitudinal component to examine whether the improved engagement of Aboriginal students is sustained over time (Recommendation 12). Further, although the study examined important factors related to Aboriginal students' engagement in science lessons, student achievement was not included. It is recommended that future studies include achievement data to add further support to the embedding of Aboriginal perspectives in science lessons (Recommendation 13). It is also recommended that studies involving the embedding of Aboriginal perspectives in science look at the influence of such programs on students' future aspirations, including whether they pursue science in further secondary and tertiary studies.

Fourth, Aboriginal people may practice the right to keep their culture secret and confidential, and restrictions may apply under customary laws. Certain aspects of culture are also restricted to "men's business" and women are not permitted to engage in such activities. For example, playing the didgeridoo that was used in this

study was restricted to the male students only. Such restrictions were limiting, the female participants were not able to engage in certain activities. It is recommended, therefore, that teachers be cognisant of these cultural protocols so as not to cause offence and to have alternate activities planned for students who may not be allowed to participate in certain activities (Recommendation 14).

Fifth, as a non-Aboriginal researcher, I was limited in my capacity to speak for Aboriginal people and lacked the connection they have to country. However, being non-White and having a shared history of racial discrimination, I was able to have an authentic voice in the study. As a result, I found that I did not encounter scepticism and resistance from the Aboriginal community I worked with. My work was viewed positively and I was reassured that my study was making a difference in the community and contributing to the Aboriginal research agenda.

Summary of Recommendations

It is recommended that ...

- Recommendation 1* Embedding Aboriginal perspectives into high school science be used as a means of turning around the disengagement towards science experienced by many Aboriginal students.
- Recommendation 2* To improve the engagement of Aboriginal students in science, educators should consider the importance of including Aboriginal students' cultural background in the teaching of science.
- Recommendation 3* Policy makers and government officials examine how teachers can be helped to make positive connections with their Aboriginal students and Aboriginal pedagogies.
- Recommendation 4* Teachers should be provided with the means to become more culturally competent, to enable them to more effectively connect and communicate with their Aboriginal

students.

- Recommendation 5* Teachers find ways to reach out and include the Aboriginal community wherever possible.
- Recommendation 6* Embedding of Aboriginal perspectives in Australian schools be formalised to strengthen the connection between Aboriginal and non-Aboriginal students and to help reduce prejudice.
- Recommendation 7* Educators consider strengthening Aboriginal students' confidence through the process of embedding Aboriginal perspectives.
- Recommendation 8* Science lessons embed Aboriginal perspectives, using learning strengths that ensure that they appeal to Aboriginal students.
- Recommendation 9* Consultation with the local community be at the forefront of any attempt to embed Aboriginal perspectives into science lessons.
- Recommendation 10* Future studies include other Aboriginal cultural groups and adapt the cultural content to suit their particular traditions and knowledge.
- Recommendation 11* Future studies include a more diverse group of research participants from a range of different cultural groups, as there are over 600 different Aboriginal cultural groups in Australia.
- Recommendation 12* Future studies include a longitudinal component to examine whether the improved engagement of Aboriginal students is sustained over time.
- Recommendation 13* Future studies include achievement data to add further support to the embedding of Aboriginal perspectives in

science lessons.

Recommendation 14 Teachers be cognisant of cultural protocols so as not to cause offence and have alternate activities planned for students who may not be allowed to participate in certain activities.

Significance

Embedding Aboriginal perspectives in science provided an innovative approach to engaging a group of Year 9 Aboriginal students in a prescribed science subject. The findings suggest that the lessons engaged the Aboriginal students by fostering connectedness, strengthening confidence, appealing to their learning strengths and changing the perceptions that they held about science. In doing so the study is significant in three main ways: it provides important theoretical understandings; it offers an innovation in methodological practice; and, lastly, the results are likely to be of practical significance to Aboriginal students, teachers, curriculum developers and pre-service and professional development providers.

My study provides a strong theoretical base by examining the key variables that guide research with and about Aboriginal people (Chapter 2). Providing these foundational guidelines to appropriate processes for researching Aboriginal people is significant, as the research agenda has changed considerably in recent years in Australia. Aboriginal people are deciding on the research agenda for Aboriginal based research, and my study provides a research framework informed by Aboriginal epistemologies, which may be of assistance to future researchers.

My study also details ways of working with a particular group of Aboriginal students (Nyoongar), of engaging with Aboriginal community members, and of balancing Aboriginal and Western research methods. This study, therefore, makes available a set of competencies, information sources, strategies and evidence to Australian researchers wishing to work with Aboriginal communities. This can be used to help researchers to establish rigour and authenticity in their research by gaining a more

informed understanding of the theoretical principles that underpin research with Aboriginal communities.

Further, the findings of my study demonstrate to international researchers how different Aboriginal communities across the globe have collaborated and shared in research innovation that is suitable for Aboriginal people. As an exploratory and interpretive study, it provides a possible platform for future research into creating new theories and practices for working with Aboriginal people.

Embedding Aboriginal perspectives in science is relatively new to Australia and, at the time of writing this thesis, was not common practice in schools. My study, therefore, in a small way, contributes to filling this gap in research and practice and provides an opportunity for future research in this area. I hope it encourages other teachers to trial embedding Aboriginal perspectives in science in Australia and thus building an Australian database.

In my study, I implemented an emergent research methodology that is relatively new to Australia (explained in Chapter 4). In contesting the constructs of traditional Western research methods, I was aware that I was a novice in the field. However, having an Aboriginal Consultative Group attached to my study mitigated this, and I was able to strengthen and contribute to this emerging field and demonstrate how this approach can be carried out effectively and localised for a specific cultural group.

While the findings from this study are specific to a particular Aboriginal group in Western Australia, they could provide a methodological approach to investigating the effectiveness of embedding Aboriginal perspectives in science in other Aboriginal cultural groups across Australia. Although every Aboriginal community has their own unique culture, by comparing the similarities and differences between each group, a range of culturally appropriate and effective ways to embed Aboriginal perspectives in science could emerge. These principles and methodologies can be transferable across different cultural groups.

My study provides information on how science teachers can embed Aboriginal perspectives in their lessons to effectively engage Aboriginal students. It demonstrates what factors are key in producing engagement, as detailed in Chapters 5 and 6. In the process, it also provides valuable pointers as to how to engage with Aboriginal parents and community, and how to observe relevant cultural protocols.

My findings also offer the opportunity to teachers to refine and validate the approaches used with their own local cultural groups. For example, ways of working with Nyoongar people in Western Australia could be adapted to working with the Gadigal people of Sydney. Educational correlations can be set up between the different Aboriginal cultural groups in Australia, thus providing rich information for teachers.

Embedding Aboriginal perspectives in science is not mandatory; hence each school decides upon the extent to which they would like this to be their focus. Unfortunately, at times most of this falls into the “too hard” and “address later” basket, as teachers who are often pressed for time in completing the set science syllabus have insufficient resources and limited access to Aboriginal community members. I am confident that this study will provide hope and encouragement to teachers, and that the process of embedding Aboriginal perspectives in science is possible and not as daunting as some may believe.

It is hoped that the findings will contribute in a small way to improving understanding of how embedding Aboriginal perspectives in the science curriculum can work. By understanding how and why this process is effective, further research and science education agendas can be extended. There are very few available resources to help science teachers and Aboriginal students to bridge the gap between Western and Aboriginal ways of knowing and doing; this study provides some foundational steps for teachers to use in working with Aboriginal people and may alert curriculum developers to the fact that more resources are required in this area.

I also raise pertinent questions about the current approach to educating Aboriginal students in Australia, which continues to be very Anglo-Saxon in nature and design.

There is a concerning decline in students studying science in Australia, and a pressing need to engage students in science by doing science in a more relevant way. My study, in a small way, has implications for pedagogy, curriculum development and resources that curriculum developers and pre-service and professional development providers can draw on and utilise for further discussion. It is a small but successfully tested model as a catalyst for change.

Concluding Remarks

Aboriginal Australians continue to be one of the most disadvantaged groups in Australia (Australian Institute of Health and Welfare [AIHW], 2016). By the time Aboriginal students reach age 10, they are already lagging behind their non-Aboriginal peers in academic achievement, and this deteriorates further in the following two years (Bradley, Draca, Green & Leeves, 2007; Hall & Patrinos, 2012). My study examines possible ways to improve the current disengagement in science education of Aboriginal students.

Even though this study was small in size, the findings indicate that embedding Aboriginal perspectives in science can be the catalyst for increasing the engagement of Aboriginal students in science. My findings indicate that, by allowing Aboriginal culture to merge into the science curriculum, issues such as disruptive behaviour, poor motivation and self-confidence are reduced. Further, maintaining and implementing Aboriginal cultural capital in the science curriculum is a viable way of making science more relevant to Aboriginal students. Admittedly this comes with many challenges, including redesigning a science curriculum and the need to improve cultural competence in teachers.

Government leadership and funding are key to advancing change of this nature. Ongoing commitment, change in policies, and a passion to bring about change will help to ensure the successful implementation of embedding Aboriginal perspectives in science. Ripples make waves, and I hope that the ripples created through the positive results of this study may help to create changes in which Aboriginal children (entrusted to schools and teachers by their parents) will be given the opportunity to

receive teachings that are complementary to and align with their core values and beliefs.

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APPENDIX A

Information Sheet and Consent Form: Students

Curtin University of Technology
Science and Mathematics Education Centre

Information Sheet

Dear Students,

My name is Jennet Hansen. I am currently completing a piece of research for my PhD of Science and Mathematics Education at Curtin University of Technology. I invite you to consider participating in this research to examine

**The effectiveness of including Aboriginal perspectives to
engage Aboriginal students in high school science**

Purpose of Research

The main aim of this research is to provide some insight into the under representation of Aboriginal students in science courses and demonstrate ways in which Aboriginal perspectives in the science curriculum can enhance the learning outcomes for Aboriginal students.

Your Role

I am interested in finding out about your experience with science as a school subject and whether the inclusion of Aboriginal perspectives will increase your engagement. A yarning session will be conducted to determine your feelings on the topic. A set of questions will be used which should take about 20 minutes. The study will be conducted over two terms to test if there are any changes in attitudes once a case study has been trialed in your classroom.

Consent to Participate

Your involvement in the research is entirely voluntary. You have the right to withdraw at any stage of the research without it affecting your rights or my responsibilities. When you have signed the consent form, I will assume that you have agreed to participate and allow me to use your data in this research.

Confidentiality

The information you provide will be kept separate from your personal details, and only myself and my supervisor will have access to this. The interview transcript will not have your name or any other identifying information on it and in adherence to university policy, the interview tapes and transcribed information will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed.

Further Information

This research has been reviewed and given approval by Curtin University of Technology Human Research Ethics Committee (Approval Number HR 30/2010). If you would like further information about the study, please feel free to contact me on 0410107810 or by email jennet.hansen@det.wa.edu.au alternatively, you can contact my supervisor, Dr. Jill M. Aldridge on +61892663592 or j.aldrige@curtin.edu.au

Thank you for your consideration in taking part in this research. Your participation is greatly appreciated.

Yours sincerely,

Jennet Hansen

STUDENT'S CONSENT FORM

The effectiveness of including Aboriginal perspectives to engage Aboriginal students in high school science

- I understand the purpose and procedures of the study.
 - I have been provided with the participation information sheet.
 - I understand that the procedure itself may not benefit me.
 - I understand that my involvement is voluntary and I can withdraw at any time without problem.
 - I understand that no personal identifying information like my name, address or school will be used in any published materials.
 - I understand that all information will be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.
 - I understand that updates of the progress of the research will be provided to me.
 - I have been given the opportunity to ask questions about this research.
 - I agree to participate in the study outlined to me.
-

Name: _____

Signature: _____

Date: _____

APPENDIX B

Information Sheet and Consent Form: Parents

Curtin University of Technology
Science and Mathematics Education Centre

Information Sheet

Dear Parents,

My name is Jennet Hansen. I am currently completing a piece of research for my PhD of Science and Mathematics Education at Curtin University of Technology. I invite you to consider participating in this research which seeks to examine

**The effectiveness of including Aboriginal perspectives to
engage Aboriginal students in high school science**

Purpose of Research

The main aim of this research is to provide some insight into the under representation of Aboriginal students in science courses and to determine whether embedding Aboriginal perspectives in the science curriculum can enhance the learning outcomes for Aboriginal students

Your Role

I am interested in finding out about your child's opinions regarding the embedding of Aboriginal perspectives in the science curriculum and how it influences your child's attitude and enrolment in science. I will interview your child for about 20 minutes. The study will be conducted over two school terms.

Consent to Participate

Your child's involvement in the research is entirely voluntary. Your child has the right to withdraw at any stage of the research without it affecting your child's rights or my responsibilities. When you have signed the consent form, I will assume that you have agreed to participate and allow me to use your child's data in this research.

Confidentiality

The information your child provide will be kept separate from her/ his personal details, and only myself and my supervisor will have access to this. The interview transcript will not have your child's name or any other identifying information on it and in adherence to university policy, the interview tapes and transcribed information will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed.

Further Information

This research has been reviewed and given approval by Curtin University of Technology Human Research Ethics Committee (Approval Number HR 30/2010). If you would like further information about the study, please feel free to contact me on 0410107810 or by email jennet.hansen@det.wa.edu.au alternatively, you can contact my supervisors: Dr. Jill M. Aldridge on +61892663592 or j.aldridge@curtin.edu.au

Thank you very much for your considerations on taking parts this research. Your participation is greatly appreciated.

Yours sincerely,
Jennet Hansen

PARENTS' CONSENT FORM

**The effectiveness of including Aboriginal perspectives to
engage Aboriginal students in high school science**

- I understand the purpose and procedures of the study.
 - I have been provided with the participation information sheet.
 - I understand that the procedure itself may not benefit me and my child.
 - I understand that my child involvement is voluntary and he/she can withdraw at any time without problem.
 - I understand that no personal identifying information like my child's name, address or school will be used in any published materials.
 - I understand that all information will be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.
 - I understand that updates of the progress of the research will be provided to me and my child.
 - I have been given the opportunity to ask questions about this research.
 - I agree that my child to participate in the study.
-

Name: _____

On Behalf Of..... (Child's name)

Signature: _____

Date: _____

APPENDIX C

Information Sheet and Consent Form: Teacher

Curtin University of Technology
Science and Mathematics Education Centre

Information Sheet

Dear Teacher,

My name is Jennet Hansen. I am currently completing a piece of research for my PhD of Science and Mathematics Education at Curtin University of Technology. I am inviting you to consider participating in this research which seeks to examine

**The effectiveness of including Aboriginal perspectives to
engage Aboriginal students in high school science**

This study will meet the requirements of The Research Ethics Committee.

Purpose of Research

The main aim of this research is to provide some insight into the under representation of Aboriginal students in science courses and determine whether embedding Aboriginal perspectives in the science curriculum can enhance the learning outcomes for Aboriginal students

Your Role

You will be expected to embed Aboriginal perspectives in your science lessons for one term to test its effectiveness in engaging Aboriginal students. You will be interviewed after the innovation to determine your views on whether this practice had any impact. The study will be conducted over two terms.

Consent to Participate

Your involvement in the research is entirely voluntary. You have the right to withdraw at any stage without it affecting your rights or my responsibilities. When you have signed the consent form I will assume that you have agreed to participate and allow me to use your data in this research.

Confidentiality

The information you provide will be kept separate from your personal details, and only myself and my supervisor will only have access to this. The interview transcript will not have your name or any other identifying information on it and in adherence to university policy, the interview tapes and transcribed information will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed.

Further Information

This research has been reviewed and given approval by Curtin University of Technology Human Research Ethics Committee (Approval Number HR 30/2010). If you would like further information about the study, please feel free to contact me on 0410107810 or by email jennet.hansen@det.wa.edu.au alternatively, you can contact my supervisor, Dr. Jill M. Aldridge on +61892663592 or j.aldrige@curtin.edu.au

Thank you very much for your considerations on taking parts this research. Your participation is greatly appreciated.

Yours sincerely,
Jennet Hansen

TEACHER'S CONSENT FORM

**The effectiveness of including Aboriginal perspectives to
engage Aboriginal students in high school science**

- I understand the purpose and procedures of the study.
 - I have been provided with the participation information sheet.
 - I understand that the procedure itself may not benefit me.
 - I understand that my involvement is voluntary and I can withdraw at any time without problem.
 - I understand that no personal identifying information like my name, address or school will be used in any published materials.
 - I understand that all information will be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.
 - I understand that updates of the progress of the research will be provided to me.
 - I have been given the opportunity to ask questions about this research.
 - I agree to participate in the study outlined to me.
-

Name: _____

Signature: _____

Date: _____

APPENDIX D

Information Sheet and Consent Form: Principal

Curtin University of Technology
Science and Mathematics Education Centre

Information Sheet

Dear Principal,

My name is Jennet Hansen. I am currently completing a piece of research for my PhD of Science and Mathematics Education at Curtin University of Technology. I am inviting you to consider participating in this research which seeks to examine

**The effectiveness of including Aboriginal perspectives to
engage Aboriginal students in high school science**

This study will meet the requirements of The Research Ethics Committee.

Purpose of Research

The main aim of this research is to provide some insight into the under representation of Aboriginal students in science courses and demonstrate ways in which Aboriginal perspectives in the science curriculum can enhance the learning outcomes for Aboriginal students

Your Role

I am interested in working together with one of your science teachers and Year 9 students in science. One of your science teacher's will be asked to embed Aboriginal perspectives in his/her lessons for a term to test the effectiveness of embedding Aboriginal perspectives in the science lessons. I request your permission to carry out this innovation which will also include Aboriginal guest presenters and community members coming into the school.

Consent to Participate

Your involvement in the research is entirely voluntary. You have the right to withdraw at any stage without it affecting your rights or my responsibilities. When you have signed the consent form I will assume that you have agreed to participate and allow me to use your data in this research.

Confidentiality

The information you provide will be kept separate from your personal details, and only myself and my supervisor will only have access to this. The interview transcript will not have your name or any other identifying information on it and in adherence to university policy, the interview tapes and transcribed information will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed.

Further Information

This research has been reviewed and given approval by Curtin University of Technology Human Research Ethics Committee (Approval Number HR 30/2010). If you would like further information about the study, please feel free to contact me on 0410107810 or by email jennet.hansen@det.wa.edu.au alternatively, you can contact my supervisor, Dr. Jill M. Aldridge on +61892663592 or j.aldrige@curtin.edu.au

Thank you very much for your considerations on taking parts this research. Your participation is greatly appreciated.

Yours sincerely,

Jennet Hansen

PRINCIPAL'S CONSENT FORM

**The effectiveness of including Aboriginal perspectives to
engage Aboriginal students in high school science**

- I understand the purpose and procedures of the study.
 - I have been provided with the participation information sheet.
 - I understand that the procedure itself may not benefit me.
 - I understand that my involvement is voluntary and I can withdraw at any time without problem.
 - I understand that no personal identifying information like my name, address or school will be used in any published materials.
 - I understand that all information will be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.
 - I understand that updates of the progress of the research will be provided to me.
 - I have been given the opportunity to ask questions about this research.
 - I agree to participate in the study outlined to me.
-

Name: _____

Signature: _____

Date: _____

APPENDIX E

Ethics Approval: Department of Education



Government of Western Australia
Department of Education and Training

Your ref :
Our ref : D10/0350811
Enquiries :

Ms Jennet Hansen
4 Newby Pass
CANNING VALE WA 6155

Dear Ms Hansen

Thank you for your completed application received 10 June 2010 to conduct research on Department of Education sites.

The focus and outcomes of your research project, *Igniting Science Education through the Dreamtimes: Effectiveness of Including Aboriginal Cultural Knowledge on Aboriginal Students' Engagement in Western Science Courses*, are of interest to the Department. I give permission for you to approach site managers to invite their participation in the project as outlined in your application. It is a condition of approval, however, that upon conclusion the results of this study are forwarded to the Department at the email address below.

Consistent with Department policy, participation in your research project will be the decision of the schools invited to participate, individual staff members, the children in those schools and their parents. Researchers are responsible for providing site managers with a copy of this letter as well as a current Working with Children Check.

Responsibility for quality control of ethics and methodology of the proposed research resides with the institution supervising the research. The Department notes a copy of a letter confirming that you have received ethical approval of your research protocol from the Curtin University of Technology Human Research Ethics Committee.

Any proposed changes to the research project will need to be submitted for Department approval prior to implementation.

Please contact Ms Liz Harrison, Policy and Planning Officer, on 9264 5168 or researchandpolicy@det.wa.edu.au if you have further enquiries.

Very best wishes for the successful completion of your project.

Yours sincerely

ALAN DODSON
DIRECTOR
EVALUATION AND ACCOUNTABILITY

11 June 2010

151 Royal Street, East Perth Western Australia 6004

APPENDIX F

Ethics Approval: Curtin University

memorandum

To	Dr Jill M Aldridge, SMEC
From	A/Professor Stephan Millett, Chair, Human Research Ethics Committee
Subject	Protocol Approval HR 30/2010
Date	12 May 2010
Copy	Associate Professor Ted Wilkes NDRI Jennet Hansen SMEC Graduate Studies Officer, Faculty of Science and Engineering

Thank you for providing the additional information for the project titled "*Igniting western science through the Dreamtimes: An investigation of the impact of Aboriginal students engagement in western science courses*". The information you have provided has satisfactorily addressed the queries raised by the Committee. Your application is now **approved**.

- You have ethics clearance to undertake the research as stated in your proposal.
- The approval number for your project is **HR 30/2010**. Please quote this number in any future correspondence.
- Approval of this project is for a period of twelve months **12-05-2010** to **12-05-2011**. To renew this approval a completed Form B (attached) must be submitted before the expiry date **12-05-2011**.
- If you are a Higher Degree by Research student, data collection must not begin before your Application for Candidacy is approved by your Faculty Graduate Studies Committee.
- The following standard statement **must be** included in the information sheet to participants:

This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number HR 30/2010). The Committee is comprised of members of the public, academics, lawyers, doctors and pastoral carers. Its main role is to protect participants. If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth, 6845 or by telephoning 9266 2784 or by emailing hrec@curtin.edu.au.

Applicants should note the following:

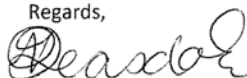
It is the policy of the HREC to conduct random audits on a percentage of approved projects. These audits may be conducted at any time after the project starts. In cases where the HREC considers that there may be a risk of adverse events, or where participants may be especially vulnerable, the HREC may request the chief investigator to provide an outcomes report, including information on follow-up of participants.

The attached **FORM B** should be completed and returned to the Secretary, HREC, C/- Office of Research & Development:

When the project has finished, or

- If at any time during the twelve months changes/amendments occur, or
- If a serious or unexpected adverse event occurs, or
- 14 days prior to the expiry date if renewal is required.
- An application for renewal may be made with a Form B three years running, after which a new application form (Form A), providing comprehensive details, must be submitted.

Regards,



A/Professor Stephan Millett
Chair Human Research Ethics Committee

PP

APPENDIX G

A guide for consultation with Aboriginal people

A guide for consultation with Aboriginal people

- I. Don't assume anything.
- II. Be honest and sincere.
- III. Use simple clear, plain and appropriate language.
- IV. Speak slowly if and when necessary.
- V. Jargon or technical language should be explained.
- VI. Don't mimic Aboriginal ways of speaking, i.e. words, slang, speech or accent.
- VII. Be open-minded.
- VIII. Never be boastful about your ideas.
- IX. Don't be too direct as this can be taken as confrontational and/or rude.
- X. Direct eye contact may also be considered confrontational and/or rude.
- XI. Emphasise the purpose of your activity and intended benefits to the community.
- XII. Don't ask hypothetical questions.
- XIII. Deal in practical real issues not theoretical ideas.

Source: 'Protocols for Consultation and Negotiation with Aboriginal People', by Huggins, Jackie, Department of Aboriginal and Torres Strait Islander Policy and Development, Brisbane, QLD,

APPENDIX H

Year 9 Term 3 Science Program 2010: Embedding Aboriginal Perspectives

Year 9 Term 3 Science Program: Embedding Aboriginal Perspectives

Topic	Prescribed Activities	Activities with Aboriginal Perspectives Embedded
Forms of energy.- Energy transformation and conservations	Relighting candles Making popcorns Energy caucus race (energy conversion)	-Science behind Aboriginal Fire Making <ul style="list-style-type: none"> • Hand drill method of making fire. • An Aboriginal Elder will demonstrate this method. • Students will also get an opportunity to have a go.
Heat energy – conduction, convection and radiation	Feeling the heat Conduction in metal rods Radiation emission Black and Brown Coffee investigation	-Students will engage in scientific inquiry, exploring how fabric choice in various cultures affects the conservation of heat and energy. A Kangaroo cloak will be brought in. <ul style="list-style-type: none"> • Healing: by heat an Elder will demonstrate how warm eucalyptus leaves can ease a toothache • Renewable and non-renewable sources • Crush charcoal for healing • Making an axe • Melting gum • Glue making • Aboriginal people often cooked their food in earth ovens. To do this, they heated stones or burnt clay lumps and placed them in a pit. • Discuss how Aboriginal people used the burn back method to ensure new growth to replenish food supplies in the bush.
Light energy – reflection	Eyeball dissection Make a zoetrope Water microscope	- Explain Min Min Lights for a different world view
Sound energy – compression and rarefaction	Energy topic test	-Science of the didgeridoo- demonstration and male students only get opportunity to try playing <ul style="list-style-type: none"> • Rain sticks and clap sticks
Forces – push or pull, balanced or unbalanced Friction force Gravitational force Magnetic forces – attraction and repulsion	Comparing friction of different surfaces Friction ball Pulling books Falling objects, measuring impact Shapes internet activity Airplane wing span investigation Forces topic test	-Explore traditional trapping methods in relation to the role of motion, push, pull, speed, and force. <ul style="list-style-type: none"> • Laws of physics and the aerodynamics behind the <i>boomerang</i>, the <i>spear</i>, and the <i>woomera</i>. • Explain the biology and chemistry behind Aboriginal food selection from nature and extraction of toxins • Include lesson on Aboriginal Scientist, David Unaipon. He invented the hand shears for shearing sheep and also drew

Topic	Prescribed Activities	Activities with Aboriginal Perspectives Embedded
		<p>sketches of a Helicopter in 1914, 16 years before it received a patent in 1930. Unaipon has been called Australia's Leonardo Da Vinci</p>
Simple machines – ramps, levers and pulleys	<p>Relationships between slope of ramp and effort Seesaw lever investigation Paperclips pulleys Simple machines topic test</p>	<ul style="list-style-type: none"> • Compare motion and friction in traditional and contemporary modes of travel (e.g. traditional bark canoes made in Arnhem Land) • Include stone cutting tools and the use of stone tools to grind seeds. • Aboriginal <i>fish-traps</i> and systems of weirs • Look at perpetual motion: David Unaipon
Static electricity	<p>Balloon race Twisting water with static electricity</p>	<p>-Integration of Aboriginal beliefs about lightning with the teaching of static electricity.</p>
Moving electricity	<p>Construction of a circuit Lemon battery cell Conductors and insulators Electric skill tester Electricity topic test</p>	<ul style="list-style-type: none"> • Integrate the use of Fibre work nets, traps, baskets and bags used by Aboriginal people for for fishing and hunting. • Explain how quartz, tourmaline crystals will generate an electrical charge when pressure is applied in the direction of the vertical axis. This is called Piezo electricity. In addition, some tourmaline will generate an electrical charge when heated.
Electrical circuit – series and parallel	<p>Construction of parallel and series circuits Measuring voltage and current in parallel and series circuits (Lab report on parallel and series circuits)</p>	<p>-Electricity generation from local rivers.</p>

APPENDIX I

**The key steps involved when considering how to embed Aboriginal Perspectives
in Science Lessons.**

APPENDIX I

Key steps when considering how to embed Aboriginal perspectives in science lessons.

- | | |
|---|--|
|  <p>1. Embrace Aboriginal histories
Have an understanding of Australian Aboriginal history and its impact on Aboriginal students</p> |  <p>2. Welcome Aboriginal culture
Have an understanding of Aboriginal culture and its importance to Aboriginal students</p> |
|  <p>3. Understand social realities
Develop an awareness of the current social realities that impact on Aboriginal students</p> |  <p>4. Position your personal standpoint
history, background and experiences in relation to your Aboriginal students</p> |
|  <p>5. Consult with your local Aboriginal community and Aboriginal staff at school
Be willing to step out into the community</p> |  <p>6. Become culturally responsive</p> |
|  <p>7. Develop Aboriginal teaching pedagogies and teaching styles .</p> |  <p>8. Innovate the science curriculum
Prepared to invest and source new ideas for curriculum change.</p> |
|  <p>9. Implement effective strategies that work for Aboriginal students.</p> |  <p>10. Evaluate and assess equitably
Be prepared to develop appropriate and culturally fair assessments</p> |

Starting Point: Embrace Aboriginal Histories

The starting point for embedding Aboriginal perspectives in science involves going back in time and gaining a clear understanding of Aboriginal students' historical positioning in Australian history. As discussed in the literature review (Chapter 3), Aboriginal people have a history dating back some 60,000 years and are one of the oldest living cultures in the world. This history includes the colonisation of Aboriginal people and the intergenerational effects which are still experienced by Aboriginal students today in current school settings. Poor health, social disruption, low educational achievement and suppression of culture, language and spirit are some of the outcomes of being colonised. Therefore, having a good understanding of

why Aboriginal students may underachieve in science in relation to what happened in the past will enable better planning and targeted initiatives for the embedding of Aboriginal perspectives.

Step 2: Welcome Aboriginal Culture into the Science Classroom

The second step to embedding Aboriginal perspectives in science is for the teacher to get to know the Aboriginal students personally and to find out about their culture from them. By getting to know the Aboriginal students in the class, the teacher will recognise that Aboriginal students bring to the classroom their cultural practices, values and beliefs that shape them as learners. Tapping into this knowledge may provide a contextual background for science lessons. Inviting Aboriginal students' parents, grandparents and community members as partners on this journey is valuable, as they have relevant knowledge to share on prescribed topics, or if they don't, they will provide links to someone else in the community.

Aboriginal people have a strong connection to their creation stories, known as their Dreaming, and a part of this is their close spiritual connection to the land. Their cultural makeup includes strong family and kinship structures and their own cultural lore. Therefore, this step in embedding Aboriginal perspectives is important, as it enables a perspective on how to include Aboriginal culture in the classroom.

Step 3: Understand Aboriginal Social Realities

In this step, I suggest that the teacher gain an understanding of Aboriginal social realities to ensure that embedding Aboriginal perspectives is meaningful and respectful. As discussed in Chapter 3, the social, cultural and historical context of Aboriginal Australians is an important consideration, as it relates to issues which will be experienced by Aboriginal students in your classroom. Aboriginal social realities are portrayed in the media on a daily basis, some of which include child abuse, drug and alcohol abuse, domestic violence, incarceration, poverty and homelessness. Hence, a culturally informed view of social realities pertaining to the Aboriginal students' lives will impact on their learning and teaching style. Table 7.1 provides a

list of useful resources from the Closing the Gap Clearinghouse website that can be used to provide teachers with an informed view.

Table 7.1: Closing the Gap Clearinghouse Papers

Title	Author
Early learning programs that promote children's developmental and educational outcomes	Harrison, Goldfeld, Metcalfe & Moore (2012)
Engaging Indigenous students through school-based health education	McCuaig, Nelson & Occthy (2012)
Early childhood and education services for Indigenous children prior to starting school	Sims (2011)
Closing the school completion gap for Indigenous students	Helme & Lamb (2011)
Teacher and school leader quality and sustainability	Mulford (2011)
Working together: Aboriginal and Torres Strait Islander mental health and wellbeing principles and practice	Dudgeon, Milroy & Walker (2014)
Recognizing Aboriginal and Torres Strait Islander peoples' rights and perspectives through civics and citizenship.	Peterson & Tudball (2016)

There are some useful links available that are related to the social, cultural and historical context of Aboriginal Australians. For example, the Working with Aboriginal and Torre Strait Islanders and their Communities website offers useful information about how you can improve your understanding (see <http://www.workingwithatsi.info/content/fyu.htm>) and the Australian Human Rights Commission website provides information about using a human rights based approach to working with Aboriginal Australians (see <https://www.humanrights.gov.au/news/speeches/social-determinants-and-health-indigenous-peoples-australia-human-rights-based>).

Step 4: Position your Personal Standpoint

The next step involves forming a personal standpoint when embedding Aboriginal perspectives in the science lessons. This is important, as acknowledging personal experiences of both the teacher and the student helps shape the interaction in the classroom. Aboriginal students enjoy yarns, and will often ask questions about the teacher and his or her family. Family is very important to Aboriginal people and a small family unit atmosphere may encourage a culturally responsive classroom. Recognising the interconnectedness of personal and professional experiences is central to working with Aboriginal students, as students also bring their histories into the classroom. A teacher could go about doing this by sharing their cultural background, beliefs and philosophies. For example, I found that sharing my apartheid background as part of my personal standpoint shaped the learning process in a beneficial way.

Step 5: Becoming Culturally Responsive

Cultural responsiveness is the ability to effectively understand, interact and communicate sensitively with people from different cultural backgrounds. In an ever-increasing multicultural Australia, becoming culturally responsive is a highly valued skill. In terms of Aboriginal students, this means being aware that Aboriginal students have a different background to the mainstream Anglo-Saxon students who are most represented in Australian classrooms. Cultural competence requires the teacher to adopt attitudes, knowledge and skills to teach these students in a way that values who they are and what they bring into the classroom. This step is now a requirement of the Australian professional standards for teachers, and various professional development opportunities are available through schools and private organisations.

From my experience, developing cultural responsiveness can be challenging, but holding positive attitudes towards cultural differences and gaining professional development in this area is highly valuable. If you are committed to respectful and reciprocal relationships, Step 5 is achievable and makes embedding Aboriginal perspectives in science achievable too. Being culturally responsive will contribute to improved learning outcomes for Aboriginal students in science, as the science

program you design will reflect Aboriginal students' cultural knowledge, beliefs and Aboriginal science.

I would urge teachers to consider examining critically their own cultural and examine ways that this can be developed and grown. Some useful links that could help teachers in this area are provided below.

The Department of Education Western Australia (2015) has recently launched the Aboriginal Cultural Standards Framework which supports teachers to improve outcomes for Aboriginal students. The framework is aligned with the Australian Professional Standard for Principals and Australian Professional Standards for Teachers. The framework supports teachers to reflect on their behaviours, attitudes and practices with a view to progressing from cultural awareness to cultural responsiveness so that they can maximise learning outcomes for their Aboriginal students. The Framework can be accessed at

<http://www.det.wa.edu.au/aboriginaleducation/detcms/navigation/aboriginal-education/>

An excellent guide to professional development and learning options for all Australian teachers – both Aboriginal, Torres Strait Islander and non-Aboriginal, can be found at:

http://www.curriculum.edu.au/leader/helping_teachers_support_aboriginal_and_torres_str,36825.html?issueID=12826.

Further professional development can also be sourced from a handbook designed by the Queensland Education Department, offering resources on the Aboriginal and Torres Strait Islander Studies senior syllabus, embedding Aboriginal perspectives across the curriculum and implementing a whole-school policy on Indigenous education. It provides guidance to teachers on how content can be selected and ideas on material to support delivery and assessment. The handbook can be found at https://www.qcaa.qld.edu.au/downloads/senior/snr_atasi_10_handbook.pdf.

Difference Differently is an online resource which is aligned to the Australian Curriculum and funded by the Department of Education, Employment and Workplace Relations. *Difference Differently* is designed to help students, teachers and others to explore the challenges and opportunities created by diversity. Fourteen online modules are provided and Australian Curriculum links and class based activities are included to supplement online learning and support classroom practice. The modules can be found at <http://www.differencedifferently.edu.au/>.

The National Education Association provides a Diversity Toolkit which teachers can access to gain Cultural Competence. Using these resources teachers can learn, practice, and institutionalise cultural competence. This toolkit can be found at <http://www.nea.org/tools/30402.htm>.

Step 6: Consult and Connect with your Local Aboriginal Community

This step involves connecting with and consulting the local Aboriginal community. Support from the local Aboriginal community will be useful in both the development and the implementation of Aboriginal perspectives in the science curriculum. If one is available at your school, the Aboriginal and Islander education officer is a good starting point, and they will be able to help you establish links with the parents, Elders and community members. Use this as a starting point to cultivate networks and also source help from other organisations focusing on Aboriginal issues, such as:

- Government departments and organisations (e.g., housing services, family services, Centrelink);
- Local service providers, both mainstream and Aboriginal-specific (e.g., drug and alcohol services, community counselling services);
- Aboriginal cultural centres and organisations;
- Universities and TAFE;
- Parenting education providers.

For more information on collaboration with Aboriginal-specific services, refer to Scougall (2008, pp. 60-62) and Soriano, Clark, and Wise (2008).

Once you have established these partnerships, you can request assistance from them for resources, presenters and curriculum design. A detailed checklist of things to consider when working and meeting with Aboriginal people is provided in Appendix G. Take note of these, as they are valuable pointers to working in a culturally appropriate way; in particular, the use of yarning (described in Chapter 4) is a culturally safe way of having a conversation with Aboriginal people. There are many relevant resources that teachers can access in this regard. For example, the Department of Education WA has designed and developed a specific website for teachers with a wide range of resources to enable them to work in a way that improves the academic performance of Aboriginal students. It also provides resources that will assist teachers to implement Aboriginal Studies in their classroom.

Go to:
<http://www.det.wa.edu.au/aboriginaleducation/apac/detcms/navigation/apac/implementing-apac/teaching-aboriginal-students/>

Another useful website is Creative Spirits which provides historical and current information about Aboriginal culture as well as teacher and student resources like infographics, films and music. Teachers can access this outstanding site at: <https://www.creativespirits.info/aboriginalculture/education/teaching-aboriginal-students>

Step 7: Develop Aboriginal Teaching Pedagogies

An important stage in embedding Aboriginal perspectives is to determine what constitutes appropriate Aboriginal pedagogy. A list of Aboriginal pedagogies and learning strengths (some of which were described in Chapters 6 and 7) are provided for teachers to access. These are also located in educational department web pages advising on the selection of appropriate pedagogies for Aboriginal students. (For examples, go to:

- https://intranet.ecu.edu.au/__data/assets/pdf_file/0016/510073/8-Aboriginal-ways-of-learning-factsheet.pdf;
- <https://vickidrozdowski.files.wordpress.com/2012/10/individual-investigation-of-a-learning-theory-aboriginal-pedagogy.pdf>;

- https://www.qcaa.qld.edu.au/downloads/p_10/snr_atasi_languages_11_strategies.pdf.

Observing what works best for the Aboriginal students in your classroom is a good starting point. When I started working with Aboriginal students, I immediately recognised that Aboriginal students enjoy hands-on, practical learning tasks. They have a keen eye for observing things and love learning through exploration. This is not to say that they should not be taught like the other students, but consideration should be given to teaching pedagogies that enhance their learning and engage them more meaningfully.

If a school has an Aboriginal Officer on the staff, utilise their services and expertise, as they are qualified to support Aboriginal students in the areas of academic achievement, participation, attendance, discipline, retention and communication. They also liaise with the community to engage parents in their children's education. For more information on their services, access the link below:

<http://www.det.wa.edu.au/aboriginaleducation/detcms/navigation/teaching-and-learning/aieo-guidelines/aieo-program/>

Step 8: Innovate the Science Curriculum

Although it is recognised that teachers have a prescribed science syllabus that must be covered, the findings of this study indicate that teaching from the science textbook may not be sufficient to help Aboriginal students reach their potential. To help to address this gap, this step aims to align relevant Aboriginal material to each unit of study. A plan for the lessons which includes the prescribed science topics and relevant links to Aboriginal content will provide a clear outline. Encouraging and fostering creativity with Aboriginal students is important to innovation and engagement.

Researching different websites and organisations for curriculum materials that would be suitable to embedding Aboriginal perspectives in science would make a suitable starting point.

The Department of Education WA has a specific website entitled Aboriginal Perspectives Across the Curriculum (APAC). This website includes information for teachers who wish to embed Aboriginal perspectives in their lessons (<http://www.det.wa.edu.au/aboriginaleducation/apac/detcms/navigation/apac/>). The specific science lesson plan form APAC can be accessed at: <http://www.det.wa.edu.au/aboriginaleducation/apac/detcms/navigation/lesson-plans/>

The living Knowledge project website is part of a three-year Australian Research Council (ARC) research project and provides resources to incorporating Aboriginal knowledge within secondary school science curricula and is available at: <http://livingknowledge.anu.edu.au/>.

Another website with numerous lesson plans with an Aboriginal focus and is a useful resource for teachers:

http://www.lsa.lutheran.edu.au/__files/f/2812/Indigenous%20Education%20Lesson%20Ideas%20&%20Information%20Links.pdf

Another useful website is the Indigenous Science Network, a web-based exchange of information and ideas from teachers, researchers and academics across the world. The site provides bulletins on the latest developments and resources in Indigenous science and can be found at: <http://members.ozemail.com.au/~mmichie/network.html>

The Indigenous Weather Knowledge (IWK) website provides useful information for both teachers and students and is a formal recognition of traditional weather and climate knowledge that has been developed and passed down by Aboriginal and Torres Strait Islander people and can be found at <http://www.bom.gov.au/iwk/>

To find out more about innovative learning and pathways for Aboriginal students, teachers can go to the National Centre of Indigenous Excellence (NCIE), and can be found at: <http://ncie.org.au/news/blog>.

The New South Wales Board of Studies has provided detailed teaching and learning resources to assist science teachers to develop programs emphasising the Aboriginal cross-curriculum content, dealing with it in culturally appropriate ways and in authentic contexts and can be found at:

http://science.uniserve.edu.au/school/curric/stage4_5/indigenousscience.html

CISRO is committed to working with Aboriginal communities to ensure sustainable futures for Aboriginal people, their culture and country. As such CISRO has developed numerous science programs to engage Aboriginal students in science through their culture. These can be accessed at:

<http://www.csiro.au/en/Education/Programs/Indigenous-STEM/I2S2/I2S2-Team>.

Some of the current trends in science thinking aim to work out ways to reimagine, rekindle, reignite or innovate science so that it is not viewed as a dull and boring subject. Similarly, this step searches for ways that science can be more interesting and engaging for students. Relating the science content through narratives, drama, dance, experiments, or any other relevant strategy will serve as effective engagement approaches. Websites and organisations for curriculum materials that would assist with embedding Aboriginal perspectives in science are abundant; suggested starting points are:

- <http://www.det.wa.edu.au/aboriginaleducation/apac/detcms/navigation/apac/>
- <http://www.det.wa.edu.au/aboriginaleducation/apac/detcms/navigation/lesson-plans/>
- <http://livingknowledge.anu.edu.au/>
- http://www.lsa.lutheran.edu.au/__files/f/2812/Indigenous%20Education%20Lesson%20Ideas%20&%20Information%20Links.pdf
- <http://members.ozemail.com.au/~mmichie/network.html>
- <http://www.bom.gov.au/iwk/>
- <http://ncie.org.au/news/blog>
- http://science.uniserve.edu.au/school/curric/stage4_5/indigenousscience.html
- <http://www.csiro.au/en/Education/Programs/Indigenous-STEM/I2S2/I2S2-Team>

Step 9: Assess and Evaluate Equitably

In this step, the science teacher considers the assessments and evaluations that are used in the science class: whether the assessment provides a fair reflection of Aboriginal students' true worth, or whether the tests include a bias (such as testing Aboriginal students on Western concepts that they may be unfamiliar, like asking Aboriginal students in a remote community why the ocean has waves). Given that tests are generally developed by non-Aboriginal assessors to target the mainstream population, they may not be a good indication of the students' ability. Therefore, when planning assessments and evaluations, the teacher should plan tests that are culturally fair, that incorporate appropriate context and language and are free of any potential bias. Some helpful websites are:

- http://www.whatworks.edu.au/upload/1311206854407_file_CoreIssues10.pdf
- <http://www.aes.asn.au/images/stories/files/conferences/2003/PAPERS/WE20%20-%20Craven%20Keynote%20paper.pdf>
- <http://www.tolerance.org/Hidden-bias>
- https://www.qcaa.qld.edu.au/downloads/publications/research_qsc_357other_01.pdf

Step 10: Celebrate Success

Celebrating the success of students at school is generally an effective way to reinforce their accomplishments and to boost their self-esteem. It has been said that teachers can make or break their students either by influencing their potential to become positive contributing members of society, or to become the self-fulfilling prophecy of the words and actions of teachers (Tripcony,2000). It is now a requirement under The Australian Professional Standards for Teachers that teachers showcase the Aboriginal and Torres Strait Islander people as global citizens and celebrate their past and present achievements (AITSL, 2012).

Celebrating with the Aboriginal and school community and honouring those who helped in the success of embedding Aboriginal perspectives is likely to reinforce, inspire, and promote the program in the community and for other teachers. I found that publicity was a good way to showcase success, by using the Education Department's School Matters newsletter and the local newspaper. As part of the celebration process for this study, students were invited to an incursion with Sci Tech, won movie tickets for a poster competition, and enjoyed Aboriginal foods with the research team.