Exploring young peoples’ understanding of scientific and cultural knowledge

Mzamose Gondwe
BSc (Imperial, UK)
This thesis is presented for the degree of Doctor of Philosophy at The University of Western Australia

School of Animal Biology
Science Communication

2014
Abstract

Students’ declining interest in science taught at school has been associated with the lack of relevance of science classroom content to students’ everyday lives. This is more pronounced for students who come from minority ethnic groups as western science is the system of knowledge that is predominately taught in science classrooms. All this is happening as schools in many countries such as Australia are becoming increasingly culturally diverse. It is therefore important to address the relevance of science education and embrace indigenous knowledge, which has been included in the Australian science curriculum. This thesis - presented as a series of four papers - investigates how students (aged 12-15 years) construct the meanings of and connections between scientific knowledge and cultural knowledge through three research activities: a group meaning map, a science and culture story box and filmmaking about science and culture.

Personal meaning maps modified for small groups and a science and culture story box designed as an informal education activity explored how students construct the meanings of and connections between scientific knowledge and cultural knowledge. Seven schools (Years 7-9, students aged 12-15, N = 190) participated in these two research activities comprising: four culturally diverse Australian schools, two Aboriginal after school homework programs and one culturally diverse school in Malawi, Africa. Three of these schools (two from Australia and one from Malawi) then participated in the filmmaking program in which students made films about science and culture.

Data were collected from group meaning maps (N = 45), the science and culture story box activity (N = 45), analyses of student produced films (N = 39) and researcher observations and interviews with students, teachers and a program coordinator (N = 39). Thematic analyses were conducted on interviews, group discussions, student films and observation notes. Data from story box activity and group meaning maps were analysed statistically.

In most groups, students perceived scientific knowledge as new and progressive and cultural knowledge as old and basic. Facts and theories were mainly used to describe scientific knowledge; seldom were concepts related to the nature of science reported. The connections that students identified between scientific knowledge and cultural
knowledge were mainly around visual and material content such as food and music as opposed to values and beliefs such as worldview. These naïve perspectives are discussed in light of meaningful intercultural understanding.

Students involved in the filmmaking program based their films on a contemporary and dynamic definition of culture. For Aboriginal students, filmmaking was an opportunity to validate Aboriginal culture, while for Malawian and multicultural students defining culture as day-to-day living enabled them to explore science in their everyday lives. Students were engaged and empowered by incorporating different funds of knowledge from their family, peers, community and popular culture during production of their films. The role of teachers in creating opportunities to explore non-traditional sources of knowledge in science classrooms was important. The Malawian students, compared to the Aboriginal students, made complex scientific and cultural knowledge connections and had more films that linked science and culture. This may be due to the Malawian students having previously had a science teacher who used locally relevant examples whilst the Aboriginal students characterized their science learning as mainly theory based and more abstract.

Observations of students during filmmaking, analysis of students’ films and interviews revealed aspects of students’ scientific, social and ethnic identities. Films about science and culture enabled students to role-play and try on scientific identities whilst for others it highlighted a perceived disconnect between cultural identity and modern society. Overall, student-generated films about science and culture facilitated intercultural understanding in multicultural classrooms and supported students observing science in everyday life.
Thesis structure, declaration of authorship and publications arising

Thesis structure

The regulations of the University of Western Australia provide for the option for candidates for the degree of Doctor of Philosophy to present their thesis as a series of papers that have been published in refereed journals, manuscripts that have been submitted for publications but not yet accepted and manuscripts that are being prepared for submission. This thesis has been structured as a series of papers, with each main chapter prepared for publication in peer reviewed journals.

All manuscripts presented in this thesis relate to intercultural science education. Each paper presents a different methodology that explores the ways in which students construct and represent the meanings of and links between scientific and cultural knowledge. The discussion in Chapter 6 integrates the findings from the four manuscripts. Each paper is presented with the original internal headings, figures and tables, however for ease of reading and flow, formatting of the thesis is uniform. Headings, figures and tables are numbered in thesis style. To avoid undue repetition a single reference list is provided and where there is overlap, cross-references have been made to previous chapters.

I was responsible for the design, conduct, analysis and write up of this study. “We” instead of “I” has been used because the manuscripts presented in this thesis are prepared for publication hence “We” reflects co-authorship and the contribution of others. All co-authors have agreed to the inclusion of the work in the thesis and their bibliographical details and contributions are outlined below. The final discussion chapter presents my personal views and is written in first person singular.


Prof. Longnecker proposed personal meaning maps to collect data; I modified them to a small group context. Prof. Longnecker assisted with recruiting schools. I conducted the group meaning map activity. I analysed the data with Prof. Longnecker who helped...
with code development. I wrote the manuscript. Prof. Nancy Longnecker edited the paper and helped with reviewer comments.

**Gondwe, M. & Longnecker, N. Objects as stimuli for exploring youths’ beliefs about cultural and scientific knowledge. (Manuscript submitted for publication). (Chapter 3)**
I conceived and developed the science and culture story box activity. I conducted the activity, collected and analysed the data and wrote the manuscript. Prof. Longnecker reviewed the theoretical framework, research question design and provided editorial guidance.

**Gondwe, M. & Longnecker, N. Bridging science and culture through youth generated films. (In preparation). (Chapter 4)**
I developed the film-making activities and facilitated the film training at all three schools. I conducted interviews with the students and teachers, analysed the data and wrote the manuscript. Prof. Longnecker provided advice on content and logistics of film training workshops. Prof. Longnecker also reviewed the paper.

**Gondwe, M. & Longnecker, N. Personal and cultural identity in youth films about science and culture. (In preparation). (Chapter 5)**
Prof. Longnecker recommended identity as a theory to interpret findings from the study. I reviewed identity literature and wrote the manuscript. Prof. Longnecker provided editorial guidance.

**Publications arising from work reported in this thesis**

Presentations


Acknowledgements

I will forever be indebted to Prof. Nancy Longnecker. Her securing funds to conduct this research and her unwavering supervision are amongst the many ways that Nancy has enriched my life. I have travelled “almost” the breadth of Western Australia, met amazing people and been involved in life changing activities. This would not have been possible without Nancy’s passionate commitment and generous support.

My partner Franco was my rock. He kept bringing me back on track when I strayed. My family and friends’ generous love and support kept me moving forward. Much love to Dad who encouraged me to focus on writing, Mom for her spiritual guidance, my sister Zilanie who is always a pillar of strength and creative genius and my brother Magoli who came to my rescue during fieldwork in Malawi.

This study is part of the Science Education Enrichment Project, a project supported by an Australian Research Council Linkage grant (LP100100640) which funded this PhD scholarship. The Science Education Enrichment Project is a partnership between the University of Western Australia, Curtin University, Graham Polly Farmer Foundation and Gravity Discovery Centre. I thank my principal and co-investigators who provided useful feedback, financial support and advice, in particular W/Professor Grady Venville who kept PhD students on track and coordinated productive meetings and Brad Whitaker, education manager at Gravity Discovery Centre for lifts to Gingin. Utmost thanks to staff at the Gravity Discovery Centre and Graham Polly Farmer Foundation for facilitating group participation and Fred Deshon for introducing me to School Rainbow. Ms. Neylon, thank you for opening your home to me. I thank principals, coordinators and teachers who provided access to their classes and students who participated in this study. Sincere gratitude to the Science Communication Research Group: Miriam for reading the thesis, Sophia for always being a kind and caring friend and the entire group for their helpful advice and constructive feedback.
**Table of contents**

Abstract .................................................................................................................................................. i

Thesis structure, declaration of authorship and publications arising .......... iii

| Thesis structure | iii |
| Publications arising from work reported in this thesis | iv |
| Presentations | v |

Acknowledgements ........................................................................................................................ vii

List of Figures ........................................................................................................................................ xii

List of Tables .......................................................................................................................................... xiii

1 Introduction ........................................................................................................................................ 14

| 1.1 Rationale | 14 |
| 1.2 Background | 14 |
| 1.3 Research questions | 16 |
| 1.4 Structure | 17 |

2 Scientific and cultural knowledge in intercultural science education:

| student perceptions of common ground | 19 |

<p>| 2.1 Abstract | 19 |
| 2.2 Introduction | 20 |
| 2.2.1 Terminology | 22 |
| 2.2.2 Intercultural understanding and development of the new Australian science curriculum | 25 |
| 2.2.3 Aboriginal education in Australia | 27 |
| 2.2.4 Education in Malawi | 28 |
| 2.2.5 Navigation between different worldviews of science and culture | 30 |
| 2.3 Methods | 32 |
| 2.3.1 Study participants | 32 |
| 2.3.2 Ethics approval | 35 |
| 2.3.3 Tool | 35 |
| 2.3.4 Data collection | 38 |
| 2.4 Data analysis | 39 |
| 2.4.1 Quantitative analysis | 39 |
| 2.4.2 Qualitative data analysis | 40 |
| 2.4.2 Methodological limitations | 44 |
| 2.5 Results | 44 |</p>
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5.1</td>
<td>Extent of scientific knowledge and cultural knowledge</td>
<td>45</td>
</tr>
<tr>
<td>2.5.2</td>
<td>Breadth of scientific knowledge and cultural knowledge</td>
<td>46</td>
</tr>
<tr>
<td>2.5.3</td>
<td>Depth of scientific knowledge and cultural knowledge</td>
<td>47</td>
</tr>
<tr>
<td>2.5.4</td>
<td>Links between scientific knowledge and cultural knowledge</td>
<td>47</td>
</tr>
<tr>
<td>2.5.5</td>
<td>Thematic analysis</td>
<td>48</td>
</tr>
<tr>
<td>2.6</td>
<td>Discussion</td>
<td>50</td>
</tr>
<tr>
<td>2.6.1</td>
<td>Differences in scientific knowledge and cultural knowledge</td>
<td>50</td>
</tr>
<tr>
<td>2.6.2</td>
<td>Embracing other cultural knowledges</td>
<td>52</td>
</tr>
<tr>
<td>2.6.3</td>
<td>Common ground</td>
<td>52</td>
</tr>
<tr>
<td>2.6.4</td>
<td>Beyond facts and content knowledge</td>
<td>55</td>
</tr>
<tr>
<td>2.7</td>
<td>Conclusion</td>
<td>56</td>
</tr>
<tr>
<td>Preface</td>
<td></td>
<td>58</td>
</tr>
<tr>
<td>3</td>
<td>Objects as stimuli for exploring youths’ beliefs about cultural and scientific knowledge</td>
<td>59</td>
</tr>
<tr>
<td>3.1</td>
<td>Abstract</td>
<td>59</td>
</tr>
<tr>
<td>3.2</td>
<td>Introduction</td>
<td>60</td>
</tr>
<tr>
<td>3.3</td>
<td>Multiculturalism in Australia</td>
<td>60</td>
</tr>
<tr>
<td>3.4</td>
<td>Representations of science and culture in informal spaces</td>
<td>61</td>
</tr>
<tr>
<td>3.5</td>
<td>Definitions of culture</td>
<td>63</td>
</tr>
<tr>
<td>3.6</td>
<td>Theoretical framework for the story box activity</td>
<td>65</td>
</tr>
<tr>
<td>3.6.1</td>
<td>Design considerations</td>
<td>67</td>
</tr>
<tr>
<td>3.7</td>
<td>Methods</td>
<td>69</td>
</tr>
<tr>
<td>3.7.1</td>
<td>Participants</td>
<td>69</td>
</tr>
<tr>
<td>3.7.2</td>
<td>Data collection</td>
<td>69</td>
</tr>
<tr>
<td>3.7.3</td>
<td>Data analysis</td>
<td>72</td>
</tr>
<tr>
<td>3.8</td>
<td>Findings</td>
<td>74</td>
</tr>
<tr>
<td>3.8.1</td>
<td>Knowledge representations</td>
<td>74</td>
</tr>
<tr>
<td>3.8.2</td>
<td>Group and cohort discussions</td>
<td>76</td>
</tr>
<tr>
<td>3.9</td>
<td>Discussion</td>
<td>82</td>
</tr>
<tr>
<td>3.10</td>
<td>Conclusion</td>
<td>86</td>
</tr>
<tr>
<td>Preface</td>
<td></td>
<td>87</td>
</tr>
<tr>
<td>4</td>
<td>Bridging science and culture through youth generated films</td>
<td>88</td>
</tr>
<tr>
<td>4.1</td>
<td>Abstract</td>
<td>88</td>
</tr>
<tr>
<td>4.2</td>
<td>Introduction</td>
<td>88</td>
</tr>
<tr>
<td>4.2.1</td>
<td>Multicultural science education</td>
<td>88</td>
</tr>
<tr>
<td>4.2.2</td>
<td>Funds of knowledge</td>
<td>92</td>
</tr>
</tbody>
</table>
4.2.3 Third (Hybrid) space ............................................................................................................... 95
4.2.4 Limitations of funds of knowledge .................................................................................... 96
4.3 Student-generated films ......................................................................................................... 97
4.4 Method .................................................................................................................................... 100
  4.4.1 Participants ....................................................................................................................... 100
  4.4.2 Filmmaking workshop ...................................................................................................... 105
  4.4.3 Data collection .................................................................................................................. 106
  4.4.4 Data analysis .................................................................................................................... 107
4.5 Findings ................................................................................................................................. 109
  4.5.1 Film topics ....................................................................................................................... 111
  4.5.2 Science content ............................................................................................................... 115
  4.5.3 Culture content ............................................................................................................... 120
  4.5.4 Engagement .................................................................................................................... 124
  4.5.5 Technical ......................................................................................................................... 129
4.6 Discussion ................................................................................................................................ 130
  4.6.1 Funds of knowledge ........................................................................................................ 131
  4.6.2 Connecting science and culture and intercultural understanding ......................... 133
  4.6.3 Engage and empower ................................................................................................... 136
4.7 Conclusions ............................................................................................................................. 137
  Preface ........................................................................................................................................ 139

5 Personal and cultural identity in youth films about science and culture .......................... 140
  5.1 Abstract .............................................................................................................................. 140
  5.2 Introduction ......................................................................................................................... 140
  5.3 Identity .................................................................................................................................. 141
    5.3.1 Social identity and cultural identity ........................................................................... 144
    5.3.2 Identity in education .................................................................................................... 146
    5.3.3 Identity in youth media ............................................................................................... 151
    5.3.4 Identity, youth, science, film ...................................................................................... 153
  5.4 Methodology ......................................................................................................................... 153
  5.5 Findings ................................................................................................................................ 155
    5.5.1 Wongani ...................................................................................................................... 155
    5.5.2 Mickey ........................................................................................................................ 161
    5.5.3 Aboriginal cultural identity ........................................................................................ 163
  5.6 Conclusions ........................................................................................................................... 171

6 Conclusions and recommendations ...................................................................................... 172
6.1 Originality and significance ........................................................................................................ 173
6.2 Students' understanding of scientific and cultural knowledge ..................................... 174
6.3 Common ground ......................................................................................................................... 175
6.4 Cultural identity ......................................................................................................................... 176
6.5 Student autonomy .................................................................................................................... 177
6.6 The role of teachers .................................................................................................................. 177
6.7 Recommendations and future research ................................................................................ 178
6.8 Conclusion ............................................................................................................................... 180

Appendix 1 Images for the science and culture story box activity in Ch 3....197
Appendix 2 Connecting science and culture lesson plan ................................................. 203
Appendix 3 Timetables for film training ................................................................................. 208
List of Figures

Chapter 2: Scientific and cultural knowledge in intercultural science education: student perceptions of common ground

Figure 2-1 Group meaning map with no links from School Magenta 2 ......................... 41
Figure 2-2 Group meaning map with links from School Brown. ................................. 41
Figure 2-3 Scientific knowledge word cloud for group ideas........................................ 45
Figure 2-4 Cultural knowledge word cloud for group ideas........................................ 45
Figure 2-5 Links between scientific knowledge and cultural knowledge word cloud.... 48
Figure 2-6 Percentage of words from group meaning maps......................................... 49

Chapter 3: Objects as stimuli for exploring youths’ beliefs about cultural and scientific knowledge

Figure 3-1 Percentage group associations of images with different knowledge domains. ................................................................................................................................. 75
Figure 3-2 Example of a group Venn diagram showing image and knowledge domain association.............................................................................................................. 76

Chapter 4: Bridging science and culture through youth generated films

Figure 4-1 Development of thematic analysis from codes to categories. ................. 110
Figure 4-2 Categories and contexts of filmmaking that invoked funds of knowledge in three schools................................................................. 112
List of Tables

Chapter 2: Scientific and cultural knowledge in intercultural science education: student perceptions of common ground
Table 2-1 Description of study participants and data collected ..................................................34
Table 2-2 Coding manual developed for thematic coding of group meaning maps .........43
Table 2-3 School group medians for links, extent, breadth and depth of words..............46
Table 2-4 Extent of cultural knowledge and scientific knowledge ideas.................................46
Table 2-5 Breadth of cultural knowledge and scientific knowledge ideas .........................47
Table 2-6 Depth of cultural knowledge and scientific knowledge .............................................47
Table 2-7 Themes in both cultural knowledge and scientific knowledge domains ........49

Chapter 3: Objects as stimuli for exploring youths’ beliefs about scientific and cultural knowledge
Table 3-1 Items used in the science and culture story box ......................................................69
Table 3-2 Description of cohorts ............................................................................................70

Chapter 4: Bridging science and culture through youth generated films
Table 4-1 Description of study participants and data collected ........................................101
Table 4-2 Film topics by school ..............................................................................................113
1 Introduction

1.1 Rationale

This investigation of student concepts of science and culture and use of films to engage a wide range of students in science learning was premised on three important issues. Firstly, school science is failing to engage students (Lyons & Quinn, 2010; Tytler, 2007). A number of factors contribute to this failure but the one most relevant to this study is students reporting that science taught in school is boring and irrelevant (Goodrum, Druhan, & Abbs, 2011; Tytler, 2007). The second important issue, which is closely related to the first, is the increasing cultural diversity of Australian classrooms (Australian Bureau of Statistics, 2012). The multicultural nature of Australian classrooms poses challenges to implementing science learning that is relevant to all students. The third important issue, which is long overdue, is the inclusion of indigenous knowledge in the Australian national science curriculum (Baynes & Austin, 2012). Malawian students face similar challenges with a Westernized curriculum that is poorly contextualized to Malawi and teachers who are not experienced with teaching indigenous knowledge in the context of science (Glasson, Mhango, Phiri, & Lanier, 2010; Phiri, 2008).

These three important issues force us to consider: how does one create a contextualized science learning experience that engages a wide range of students from multicultural backgrounds?

1.2 Background

Recurring themes reported by Australian students that researchers have associated with students’ declining interest in science include irrelevance of science content (Goodrum, Hackling, & Rennie, 2001; Lyons, 2006; Osborne & Collins, 2001), limited opportunities to pursue areas of interest in science classes (Goodrum, et al., 2011; Tytler, 2007) and a lack of activities in science classes that encourage creativity and expression (Lindahl, 2003; Osborne & Collins, 2001).

The Choosing Science study, a study of 589 Australian school science teachers and 3759 Year 10 students who had chosen their subjects for Year 11, claims that declines in interest in science are unlikely to have contributed (Lyons & Quinn, 2010) to the fall
in enrolments of Australian students choosing to study science in Year 12 from 90% of the Year 12 cohort to 50% (Goodrum, et al., 2011). Instead the Choosing Science study reports that “failure of school science to engage a wider range of students” is one of three factors contributing to declining enrolments (Lyons & Quinn, 2010, p. i). However the authors of the study did not elaborate on what is meant by a “wider range of students”. The other two factors were “the difficulty many students have in picturing themselves as scientists” and “the decrease in the utility value of key science subjects relative to their difficulty” (Lyons & Quinn, 2010, p. i). The Choosing Science study indicates that a third of students are bored by science lessons, a quarter dislike science and rural and remote students enjoy science less.

Similar findings of small numbers of students reporting liking science were found from the Students Like Learning Science scale in the 2011 Trends in International Mathematics and Science Study (TIMSS) which showed only 25% of Year 8 students like learning science (Thomson, Hillman, & Wernert, 2012). In comparison to other developed countries, Australian students score lower on interest in science and enjoyment of science according to the Program for International Student Assessment (PISA) 2006 (Thomson & De Bortoli, 2008).

The Status and Quality of Year 11 and 12 Science in Australian Schools, a comprehensive study of students, teachers, parents, scientists commissioned by Australia’s Office of the Chief Scientist found the science curriculum was overloaded and teaching focused mainly on theory and principles which were taught in a didactic manner (Goodrum, et al., 2011). Of the students surveyed, 65% reported rarely pursuing areas of interest in class.

Malawian students report a strong interest in science, but perform poorly in science (Mbano, 2003). Factors associated with this include a poorly contextualized and overburdened curriculum and didactic teaching (Dzama, Holtman, Kolsto, & Mikalsen, 2008; Dzama & Osborne, 1999), factors which are similar to the Australian context.

Data from international assessments to compare Australia and Malawi are not available because they have participated in different studies - Australia in the TIMSS and PISA and Malawi in the Relevance of Science Education (ROSE). The ROSE international study of secondary students’ perspectives on science learning, interestingly found
attitudes towards science are more negative with increased level of country’s development (Schreiner & Sjøberg, 2007).

Another relevant comparable point between Australia and Malawi is the inclusion of indigenous perspectives in the science curriculum. The inclusion of indigenous knowledge in the Australian national curriculum – although generally welcomed as respecting Aboriginal and Torres Strait Islanders as the First people of Australia – has received mixed responses from teachers. In both countries, studies have found teachers expressed difficulty in incorporating indigenous content and some teachers held negative views of indigenous knowledge (Baynes & Austin, 2012; Glasson, et al., 2010; Phiri, 2008).

Particularly pertinent to the Australian context is that students’ perceived irrelevance of science learning and incorporation of indigenous knowledge is occurring in classrooms that are increasingly multicultural. Australia is culturally diverse; one in four of Australia’s 22 million people were born overseas, 260 different languages are spoken and over 270 ancestries are recognised (Department of Immigration and Citizenship, 2011).

Amongst the recommendations of Australian national reports of science education such as Choosing Science (Lyons & Quinn, 2010), The Status and Quality of Year 11 and 12 Science in Australian Schools (Goodrum, et al., 2011) and Re-imagining Science Education Engaging Students in Science for Australia’s Future (Tytler, 2007), are that science learning should be meaningfully and personally relevant to students’ lives and that pedagogy be flexible to allow students to pursue areas of interest.

1.3 Research questions

Using the term culture to equate to students’ personal experiences is discussed thoroughly in Chapter 2. This thesis investigated Australian and Malawian students’ understanding of scientific and cultural knowledge and the relationship between the two conceptions. Specifically, I have asked

i. How do young people define scientific knowledge and cultural knowledge and what connections and comparisons do they make between scientific knowledge and cultural knowledge?
ii. How do young people construct their conceptions of scientific and cultural knowledge?

iii. Are student-generated films about science and culture able to bridge home and school worlds? What types of funds of knowledge do students draw on and to what effect?

iv. What does participation in filmmaking about science and culture reveal about students’ identities?

1.4 Structure

This thesis is, presented as a series of papers in accordance with Doctor of Philosophy rule 33. (1) of the University of Western Australia. Each of the four main chapters are manuscripts that have been prepared or submitted for publication. The manuscript from Chapter 2 has been accepted for publication in the journal, *Research in Science Education*. The manuscripts can be read as separate entities; each has its own introduction, methodology, results and discussion. However, to avoid repetition in the thesis certain sections have been presented once with cross-references provided in other chapters to relevant sections. Descriptions of links between chapters have been provided as prefaces to aid the reader. A single reference list combines references from all the chapters. A general discussion and conclusion integrates the findings from all four manuscripts.

This first chapter provides the rationale for and background of the study that led to the proposed research questions.

Chapter 2, ‘Scientific and cultural knowledge in intercultural science education: student perceptions of common ground’, examines student perceptions of the meanings of and relationships between scientific and cultural knowledge. We discuss the lack of consensus on the definition of culture and what this means for students’ interpretation of the term. We provide rationale for using the term “cultural knowledge” in this study. The development of our research tool – group meaning maps – is also described. Findings from group meaning maps produced by students in six Western Australian schools and one Malawian school are presented. These findings are framed in the context of science education in Malawi and Australia and intercultural understanding in Australia.
Chapter 3, ‘Objects as stimuli for exploring youths’ beliefs about cultural and scientific knowledge’, is set within an informal science education context. Through an object-based activity – a science and culture story box – youths’ beliefs about scientific and cultural knowledge representations are explored. Thematic analysis of six Australian youth cohorts’ discussions reveal themes and perspectives that speak to students’ beliefs about scientific knowledge, cultural knowledge and Australian national identity.

Filmmaking about science and culture was a strategy to engage students in intercultural science education in three schools (two in Australia and one in Malawi); this is presented in Chapter 4. Funds of knowledge is the theoretical framework used to examine how, in what ways and to what effect students bridged their home and school worlds. Qualitative analysis of interviews of teachers and students, observations of the process and examination of student-generated films show how filmmaking about science and culture engaged and empowered students and facilitated intercultural understanding in multicultural contexts.

In Chapter 5, Personal and cultural identity in youth films about science and culture, we discuss three themes related to identity that emerged from our study: the affordances of filmmaking to role play scientific identities, the tension between in-school and out-of-school identities and Aboriginal cultural identities in modern and multicultural contexts. This chapter relates to the third research question “What does filmmaking about science and culture reveal about students’ identities?” The exploration of students’ identities was not anticipated in the original study design; however the wealth of data collected during the course of the research and the value of identity as a theoretical framework in science education led us to conduct an examination of students’ identities. This is illustrated through the stories of two actual students, Wongani and Mickey (pseudonyms), and interviews with students and teachers.

The discussion, Chapter 6, integrates the findings from the four manuscripts and provides recommendations for developing science learning experiences that support students’ cultural identities.
2 Scientific and cultural knowledge in intercultural science education: student perceptions of common ground

2.1 Abstract

There is no consensus in the science education research literature on the meanings and representations of western science and indigenous knowledge or the relationships between them. How students interpret these relationships and their perceptions of any connections has rarely been studied. This study reports student perceptions of the meanings of and relationships between scientific knowledge and cultural knowledge. Personal meaning maps adapted for small groups were conducted in seven culturally diverse schools, school years 7-9 (with students aged 12-15 years) ($n = 190$), with six schools in Western Australia and one school in Malawi, Africa. Of the six Australian school groups, two comprised Australian Aboriginal students in after school homework programs and the other four school groups had a multicultural mix of students. Students in this study identified connections between scientific knowledge and cultural knowledge and constructed connections from particular thematic areas - mainly factual content knowledge as opposed to ideas related to values, attitudes, beliefs & identity. Australian Aboriginal students made fewer connections between the two knowledge domains than Malawian students whose previous science teacher had made explicit connections in her science class. Examples from Aboriginal culture were the most dominant illustrations of cultural knowledge in Australian schools even in school groups with students from other cultures. In light of our findings, we discuss the construction of common ground between scientific knowledge and cultural knowledge and the role of teachers as “cultural brokers” and “travel agents”. We conclude with recommendations on creating learning environments that embrace different cultural knowledges and that promote explicit and enquiring discussions of values, attitudes, beliefs & identity associated with both knowledge domains.

Key words: scientific knowledge, cultural knowledge, border crossing, worldview, multicultural, indigenous knowledge, Aboriginal, intercultural
2.2 Introduction

There is debate in science education research on the meaningful representation and relationship of the concepts of indigenous knowledge and science (McKinley & Stewart, 2009; Snively & Corsiglia, 2001). While researchers debate, students construct their own meaning of these terms based on their home, community and school experiences. Our study investigated what meaning and connections students assign to these conceptions as few studies in the literature have sought to do.

Several metaphors and analogies exist for indigenous knowledge: traditional ecological knowledge, traditional knowledge, indigenous science and ethnoscientific knowledge (Snively & Corsiglia, 2001). Science, especially that taught at school, is usually couched in terms of its association with western systems but is rarely explicitly referred to as western science, western modern science or Eurocentric science (Aikenhead & Ogawa, 2007). The meaning and relation of the concepts of science and indigenous knowledge are highly contested. On the one hand, a reading of the debate as McKinley, Stewart, & Ritchie (2009) present it summarizes universalism, the dominant view, that puts forward western science as the most powerful and useful knowledge system ignoring contributions from other cultures to science (Good, 1995).

On the other hand, there is multiculturalism, a relativistic viewpoint that embraces different knowledge systems and promotes the ideology of all cultures possessing knowledge and beliefs concerning the natural world. The multiculturalists’ view is supported by a number of science educators that research indigenous science including Aikenhead and colleagues (Aikenhead, 1996; Aikenhead & Jegede, 1999) who object to the indigenous knowledge-western science dichotomy and have promoted the construction of “mental bridges” to enable the inclusion of indigenous knowledge in the science curriculum in many contexts including Canada and Taiwan (Aikenhead, 1997, 2001; H. Lee, Yen, & Aikenhead, 2012). As Aikenhead’s “bridge” metaphor sets indigenous knowledge and western science in two different places, Brandt (2007) proposes using the term “common ground”. She suggests that by identifying the common ground that exists, educators can make attempts to work across any perceived differences, breaking down the divides and reconstructing the science and indigenous knowledge relationship. This is echoed in ideologies like third space which merges
knowledge and Discourses from the first space – people’s homes, peers and community and the second space – institutions such as church, school and work (Moje, et al., 2004). Gee (1996) distinguishes Discourses (with a capital D) from discourses (small d); discourses refer to language activities (reading and writing) while Discourses are defined as ways of knowing, reading, writing, valuing, interacting, doing, talking and representing oneself that are embedded within sociocultural practices.

Regardless of the ongoing dominant versus multiculturalism debate in science education, students develop their own meanings of indigenous knowledge and western science. How they construct this is especially pertinent in contexts like Australia which has a rich but disrupted Aboriginal history and classrooms with an increasingly diverse cultural mix of students (Australian Bureau of Statistics, 2012). There are a number of studies on Aboriginal science education in Australia but few that have looked jointly at Aboriginal knowledge and other indigenous knowledges (Michie, 2002).

Malawi, a country in the southeast of Africa, provides an interesting comparison case study in having a history also punctuated by British colonization. On independence in 1964, the predominantly indigenous Malawian government maintained the colonial education system that did not recognize indigenous knowledge. In contrast to Australia, the population of Malawi is mainly indigenous. Malawian educators however are only now beginning to attempt to contextualize western science with local indigenous examples (Phiri, 2008).

Research methodologies in the area of indigenous knowledge in science education have included interviews or survey responses from students and teachers (Austin & Hickey, 2011; Guerra-Ramos, Ryder, & Leach, 2010; Shumba, 1999), teachers’ reflective journals (Ogunniyi, 2007), critical analysis of national curricula (Ogunniyi, 2007; Shumba, 1999), ethnographic studies of classrooms and observational data (Phiri, 2008). Few studies have gone beyond using survey instruments and interviews to assess students’ views on the nature of science and indigenous knowledge (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). According to Lederman et al’s (2002) comprehensive review of the literature on instruments that assess learners’ views on the nature of science, paper and pencil instruments are unable to elicit faithful and meaningful representations of students’ understanding. This study uses personal meaning maps (Falk & Storksdieck, 2005) adapted to a group context to explore students’ views on the
relationship between cultural knowledge and scientific knowledge. We explore how students from different cultural backgrounds in both Australia and Malawi conceptualise the complex relationship between western science and indigenous knowledge. Incorporating cultural knowledge in the science curriculum is beneficial to all students (Baynes & Austin, 2012). A common ground between cultural and indigenous knowledge may help Aboriginal students and students from other cultures relate to science and develop positive cultural identities; this could lead to improvements in access, participation and retention in science of Aboriginal students and students from other cultures (H. Lee, et al., 2012). Teaching non-Indigenous Australian students about connections between western science and cultural knowledge can challenge stereotypes, break down cultural barriers and encourage interaction between diverse communities (Cobern & Loving, 2004; Hodson, 1993). This will contribute to developing students as critically conscious global citizens (Ladson-Billings, 1995).

2.2.1 Terminology

Culture can be described as a

cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment.

(Berkes, Colding, & Folke, 2000, p. 1252)

The definition of culture, as with definitions of science and indigenous knowledge, is contested (Parsons & Carlone, 2013). The Australian Curriculum document on general capabilities refers to this by saying “the definition of the term ‘culture’ is itself not agreed upon.” (Australian Curriculum Assessment and Reporting Authority, 2012, p. 85). Culture has also been used synonymously to mean indigenous knowledge as defined above (Snively & Corsiglia, 2001). The Intercultural understanding capability in the Australian Curriculum adopts the Shape of the Australian Curriculum: Languages (ACARA 2011) definition of culture as involving:
... a complex system of concepts, values, norms, beliefs and practices that are shared, created and contested by people who make up a cultural group and are passed on from generation to generation. Cultural systems include variable ways of seeing, interpreting and understanding the world. They are constructed and transmitted by members of the group through the processes of socialisation and representation. (p.16)

The above definitions of culture are common views. Seiler (2013) writes that these views insinuate that cultures are multiple, that different societal groups have different cultures and that there is no overlap between cultures. The limitation of this pluralizable, discontinuous view of culture, she says, is that it creates an expectation that cultures are different from one another and that each culture is homogenous. In spite of these limitations, we have adopted the Berkes et al. (2000) definition of culture to describe indigenous knowledge for the purpose of this study because the multiple view of cultures is taught in schools and there is a significant overlap between indigenous knowledge and culture as described in the Australian curriculum.

In Australia, there are many conventions to refer to the original inhabitants, including First Nations, First people or First Australians. Some terms are not as widely accepted as others. The Australian government uses Indigenous to refer collectively to Aboriginal and Torres Strait Islander peoples. Indigenous was the common term but Aboriginal (capital A) people (ab origine Latin for from the beginning) is the more accepted term which shows respect and differentiates Australian Aboriginal people from aboriginal people all over the world (Munro, 2007). In accordance with the Department of Education, Western Australia policy, we use the word Aboriginal to refer to Aboriginal, Torres Strait Islander and Indigenous peoples of Australia (Department of Education Western Australia). In the instances where others have used Indigenous to refer to Australian Aboriginal people, we have kept original authors’ terminology to avoid misrepresentation. Where we have used indigenous, we are referring to the first peoples or the original inhabitants of an area in an international context. As a result of still common usage of Indigenous – indigenous knowledge is often associated with Aboriginal knowledge. To promote inclusivity and participation in this research by students from other cultures (Asia, Europe, Africa) and Australian non-Aboriginal students (predominantly Anglo-Australian) and to support the relativistic framework that recognises indigenous sciences, we have used the term culture and cultural
knowledge instead of indigenous knowledge to embody Berkes et al.’s (2000) definition of culture.

The definition of science is also sometimes considered controversial and is not usually labelled explicitly as “western modern science” (Ogawa, 1995). Australian and Malawian curriculum descriptions of science do not label it as a western endeavour (Australian Curriculum Assessment and Reporting Authority, 2012; Phiri, 2008). The connection between science and Eurocentric perspectives dates as far back as the 1830s, when the British Association for the Advancement of Science adopted the term “science” (Latin: scientia which is knowledge) to distinguish the Association from natural philosophers and technologists (Aikenhead & Ogawa, 2007). The adoption of the term science aimed to confer on the Association a privileged position. Science is a way of knowing nature. This definition as Aikenhead and Ogawa (2007) observe subsumes and includes knowledge appropriated from non-European cultures. Such knowledge was adopted and adapted to suit a Eurocentric worldview. Ogawa, describes science as a “rational perceiving of reality” (p 588). By specifically using the term ‘perceive’, a dynamic view of science is enabled (Ogawa, 1995). In this version, western science is one amongst many forms of science, where science can be simplified to mean knowledge and not solely belonging to the West. This echoes views from scholars in New Zealand (McKinley, 1996), South Africa (Le Grange, 2007) and Nigeria (Jegede, 1995) who assert that science is “simply knowledge” where a qualifier like western or indigenous is required.

Cobern and Loving (2004) object to incorporating indigenous knowledge within science. They stress that indigenous knowledge is devalued when attempts are made to use scientific frameworks to describe it. They recommend indigenous knowledge standing on its own and valued for its own merits. As we sought to understand student conceptions of science and in particular whether students associated it with the dominant universal Eurocentric view, we refer to ‘science’ in this study as western science, deeply rooted in Ancient Greek and European culture that often does not overtly recognise indigenous knowledge as a valued knowledge system. Our distinguishing science in this way does not reflect our personal worldviews, as we uphold Aikenhead’s multicultural sciences standpoint. Our aim in making this distinction is not to reinforce a hegemonic discourse but for the purpose of this study to determine what sense students make out of the science - cultural knowledge discourse.
Do students organize their discourse around similarities and differences, whole and/or parts? What have they learned about these metaphors? We thus explore whether students have been encultured in a dominant western view of science.

2.2.2 Intercultural understanding and development of the new Australian science curriculum

There are increasing global calls for recognition of indigenous knowledge in both science education and research contexts as well as in teaching that is centred on the values of students as global science citizens (Chiu & Duit, 2011; Raymond, et al., 2010; Snively & Corsiglia, 2001). The Australian Education Ministers’ response to this was the release in 2008 of a national declaration - *Melbourne Declaration on Educational Goals for Young People* (Ministerial Council on Education Employment Training Youth Affairs, 2008). This declaration formed the foundation of the general capabilities in the Australian science curriculum namely: literacy, numeracy, Information and Communication Technology (ICT) capability, critical and creative thinking, personal and social capability, ethical behaviour and intercultural understanding (Australian Curriculum Assessment and Reporting Authority, 2012).

Intercultural understanding together with the cross curriculum priorities: Aboriginal and Torres Strait Islander histories and cultures and Asia and Australia’s engagement with Asia, are strongly linked with the increasing ethnic diversity of Australia. This diversity is a result of large scale immigration in the last 40 years. The 2011 Census revealed that 26% of Australia’s population was born overseas and a further 20% have at least one parent born overseas (Australian Bureau of Statistics, 2012). The diversity of Australian residents can be seen in the variety of languages, birthplaces, ancestries and religions. The Australian Bureau of Statistics notes that although ancestry does not necessarily relate to a person’s place of birth it does give an indication of the cultural group a person most identifies with. The 2011 Australian census asked people to provide a maximum of two ancestries they identify with; English (36%) and Australian (35%) were the most commonly reported followed by Irish (10.4%), Scottish (8.9%), Italian (4.6%), German (4.5%), Chinese (4.3%) and Indian (2%) (Australian Bureau of Statistics, 2012). All these cultures engage with the world in their own way through varying traditions and religious practises. They have their own worldview, a framework about the world and life that encompasses ethics, values, philosophy and comprehensive
belief systems including religion and spirituality that are used in the construction and application of knowledge (Aikenhead & Jegede, 1999; Cobern, 1996). For example, Aboriginal peoples’ knowledge of the land and how it is formed is connected to their spirituality, The Dreaming. On the other hand Eurocentric scientific worldviews emphasize empirical testing – the scientific method (Cobern, 1996). As a result of these different worldviews, students from culturally diverse backgrounds have varied learning styles that should be addressed by multicultural education (Cobern, 1996).

Previous attempts had been made to address the growing multicultural nature of Australian classrooms by including examples of scientific contributions of different cultural groups into curriculum textbooks (Banks, 1991; Ninnes, 2000). However, this has not been matched with a change in teaching methods to suit the multicultural nature of the increasingly global classroom (Rothstein-Fisch, Greenfield, & Trumbull, 2003). Swetnam (2003) has argued that the multicultural teaching and lesson plans that were incorporated into Australian curricula have done little to integrate diversity in learning. She advocates for more intensive multicultural teacher training programs and curriculum resources.

The disconnect between multicultural education theory and practice is further highlighted in a study by McInerney (2003). She examined the attitudes of 354 teachers in New South Wales, Australia towards multicultural education from 1979 to 2000. She found that teachers had maintained the view that once a student can speak English, no further attempts at multicultural inclusion are necessary and that schools are not responsible for cultural maintenance. This underscores the need for targeted school programs that recognize and support different worldviews of ethnic minority students. In the 2012 Australian science curriculum, priority is given to the founding status of Aboriginal and Torres Strait Islander people but the science curriculum also acknowledges the importance of maintaining relations and understanding with people within the Asia-Pacific region and other countries.

Students develop intercultural understanding as they learn to value their own cultures, languages and beliefs, and those of others. They come to understand how personal, group and national identities are shaped, and the variable and changing nature of culture. The capability involves students in learning about and engaging with diverse
cultures in ways that recognise commonalities and differences, create connections with others and cultivate mutual respect.

There are opportunities in the Science learning area to develop intercultural understanding. Students learn to appreciate the contribution that diverse cultural perspectives have made to the development, breadth and diversity of science knowledge and applications (Australian Curriculum Assessment and Reporting Authority, 2012, p. 14)

2.2.3 Aboriginal education in Australia

There have been improvements in access, participation and retention in school of Indigenous Australians but there are still large differences in outcomes (pass rate, retention, literacy) between Indigenous and non-Indigenous Australians (McConney, Oliver, Woods-McConney, & Schibeci, 2010; Mellor & Cooringan, 2004). In a secondary analysis of the Programme for International Student Assessment (PISA) 2006 data McConney et al. (2010) confirm previous findings by Thomson and De Bortoli (2008) of the inequitable educational outcomes between Indigenous and non-Indigenous Australians. De Bortoli and Thomson (2010) attribute the low performance of Indigenous Australians to the socioeconomic disadvantage of Indigenous students and students’ attitudes, engagement, motivation and beliefs. McConney, Oliver, Woods-McConney, and Schibeci’s (2010) study suggests reading literacy is the cause of Indigenous students’ low performance in science, despite having equal interest in science to their non-Indigenous peers. In further analysis, they suggest that socioeconomic status, time spent on science lessons and study and the character of science teaching experienced by students are associated with science literacy (Woods-McConney, Oliver, McConney, Maor, & Schibeci, 2011). Regardless of the differences in the factors researchers attribute to the low performance of Aboriginal students, studies consistently support the revision of the school curriculum to acknowledge and value Aboriginal knowledge (Austin & Hickey, 2011; Baynes & Austin, 2012).

Indigenous knowledge informs science in areas such as ethnobotany, agroforestry, agroecology and resource management (Hunting, 2000). In Australia, Aboriginal knowledge, also known as traditional ecological knowledge, is increasingly called upon for sustainable management of resources like water and wildlife and for burning of bushlands (Horstman & Wightman, 2001). Research undertaken in the Kakadu
National Park in northern Australia by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) showed that the historical burning by Aboriginal people controlled the native grass mudja. Burning mudja promoted the growth of wetland plants and maintained biodiversity (Russell-Smith, et al., 1997). This research together with an increasing number of programs provide pathways to incorporate Aboriginal knowledge in school science curricula (e.g. Embedding Indigenous Science by the University of Sydney; Living Knowledge by the Australian National University; Primary Connections by Australian Academy of Science). However the impact on student perceptions of indigenous knowledge and its relationship to western science has not been intensively studied (Hackling, Peers, & Prain, 2007).

Few studies have actually looked at Aboriginal students’ perceptions of incorporating Aboriginal knowledge into the science curriculum and school practices. One study noted problems that urban Aboriginal students had with promoting Aboriginal culture in schools (C. Reid, 2001). The Aboriginal students in that study objected to being considered bereft of their culture and opposed the imposition of traditional Aboriginal culture e.g. traditional bushtucker and wearing Aboriginal attire. They recognized the need to appreciate their culture and family history but expressed a greater interest in associating with African American rap culture. This suggests that a suitable cultural medium that recognizes both traditional culture and modern culture is required to address the conflict that urban Aboriginal students may experience when Aboriginal knowledge is taught in a science classroom.

2.2.4 Education in Malawi

A school in Malawi provides an interesting comparison to the Australian schools in this study. Malawi has a similar fractured history of colonization and dispossession to Aboriginal Australia but without experiencing the tragic forced removal of Aboriginal children from their families (Bretherton & Mellor, 2006). Unlike Australia, Malawi was given independence from Britain in 1964 and a predominantly indigenous population runs the current Malawian government. The first author of this study is a native of Malawi and maintains close connections with schools in Malawi. Australia and Malawi have similar colonial histories and education systems yet different economic status. The comparison and contrast as well as access to a Malawian school that is similar in many ways to the Australian schools in this study (as described later) is what led us to conduct
part of this study in Malawi. A brief description of the context of education in Malawi is provided to facilitate interpretation of this study’s results.

Malawi is a landlocked country in the southeast of Africa. It has a population of 14 million who predominantly live in rural areas (80%) (Chimombo, Kunje, Chimuzu, & Mchikoma, 2005). The estimated GDP in 2009 was $4.57 billion. The official language and language of instruction is English. Primary education in Malawi is not compulsory but has been free since 1994. Malawi does not participate in international assessments like the Program for International Student Assessment (PISA) or Trends in International Mathematics and Science Study (TIMSS). Malawian students were surveyed in the Relevance of Science Education (ROSE) project, an international study to assess factors that influence young peoples’ attitudes and motivations to learn science. A compelling finding of the ROSE project is that young people in less developed countries showed more interest in learning science (Schreiner & Sjøberg, 2007). Malawian student responses were even more positive than other developing countries which researchers suggest may be due to social desirability bias, where students gave what they thought was the right answer rather than how they felt (Dzama, et al., 2008).

Malawi provides a good comparative context for this study as a developing country that has reformed its science curriculum to include aspects of indigenous knowledge (Phiri, 2008). Malawian teachers experience similar challenges to their Australian counterparts in implementing a science curriculum that incorporates indigenous knowledge. Heads of science departments in Australia schools have commented on the difficulty of incorporating indigenous knowledge in the science classroom, citing issues like lack of indigenous content in text books and teachers questioning whether indigenous knowledge is really science (Baynes & Austin, 2012). This is analogous to reports on Malawian teachers’ negative attitudes to incorporating indigenous knowledge in the science curriculum (Glasson, et al., 2010). In a study of sustainability science education, Malawian teachers used less relevant western examples even when elders in the community held an extensive knowledge of appropriate traditional sustainable farming practice (Glasson, et al., 2010). This suggests that Malawian teachers may face difficulty in scientifically explaining indigenous knowledge.

Indeed Phiri’s study (2008) found that design of the curriculum, teachers’ inadequate background knowledge in science and teachers’ negative attitudes to indigenous
knowledge in the science classroom were the main difficulties faced by Malawian teachers. A study by Dzama et al. (2008) found students attributed their poor performance to unqualified teachers and lack of science equipment, failing to see themselves as contributing factors. Dzama et al. (2008) suggest the poor performance of Malawian students in the science classroom is a failure of the school system to go beyond rote learning to cater to more diversified learning styles. The criticisms of poorly contextualised science education that have been made in both Malawi and Australia are widespread around the world (Stocklmayer, Rennie, & Gilbert, 2010) and so it is highly likely that the findings from this study will resonate elsewhere.

2.2.5 Navigation between different worldviews of science and culture

Aikenhead, a pioneer multicultural educator, conceived the term “border crossing” to describe how students move intellectually between the world of their everyday life and the world of school science and how they deal with the cognitive and contextual differences of these two worlds (Aikenhead, 1996). Multicultural and indigenous science educators commonly refer to Aikenhead’s border crossing theory to explain the learning difficulties indigenous students and students from other cultures may experience in a science classroom (Snively & Corsiglia, 2001). According to Aikenhead, enculturations occur when the school science is similar to a student’s life-world culture; the school instruction will therefore support the student’s worldview. However, assimilation occurs when the culture of school science and the student’s worldview are disparate and then the student’s worldview is marginalized. Assimilation can cause harmful social disruptions that are not conducive to learning and can alienate students from an indigenous worldview (Aikenhead, 1996). Jegede (1995, 2000) proposed collateral learning to explain how Indigenous students construct scientific concepts side by side, without any interaction or interference between the Indigenous and western concepts. Parallel collateral learning is a compartmentalization technique. Conflicting concepts do not interact, student’s access one or the other depending on the context. In secured collateral learning, the conflicting schemata consciously interact and the students are able to resolve conflict between two ideas. A secured collateral learner is able to combine western science with their indigenous knowledge. Dependent collateral learning is when schema from one domain or worldview challenges the other worldview. The student will then slightly modify either the knowledge domain or worldview to address the conflict. Simultaneous collateral learning occurs at the
junction between parallel and dependent learning. The learning of a concept in one domain feeds into learning of a similar concept in another domain. Aikenhead and Jegede (1999) point out that students from both western and indigenous backgrounds can experience this alienation from science.

We recognise that within and across classrooms, there is a spectrum of worldviews that students bring into school. On the one hand, there are students whose everyday life knowledge relies heavily on cultural knowledge passed down through family and community; therefore effective teaching must acknowledge these cultural perspectives. For example, in an ethnographic study of indigenous knowledge in a Taiwanese context, Lee, Yen and Aikenhead (H. Lee, et al., 2012) recommend that in order to motivate students’ interest and improve school performance, teachers should use students’ worldview as the foundation where indigenous knowledge and western science are combined. On the other hand, Schreiner and Sjøberg (2007) advance identity as the theoretical frame in which to understand the declining interest in science by students in modern western societies. They surmise westernised youth are less bound to cultural, social and political structures and have the liberty to create their own identities. They speculate that science education does not present images of science that correlate with youth identities and youth values of self realisation, creativity and innovation (Schreiner & Sjøberg, 2007). We note that worldview is linked to identity in guiding interpretations, social interactions and motivations. Whether worldview or identity is used as a theoretical frame, both terms have at their heart attempts to understand how students relate to the world (Kozoll & Osborne, 2004).

Our study was conducted to provide insight into how students assign meaning to science and cultural knowledge, important attributes of worldview and identity. By asking students to list ideas they associate with scientific knowledge and cultural knowledge, we explored what meaning and relationships students assigned to these complex conceptions. We acknowledge that posing scientific and cultural knowledge to students as two separate conceptions is problematic. We are by no means suggesting they are disparate. Students were permitted and encouraged to make one-to-one relationships. Our research examined whether students view scientific and cultural knowledge as mutually exclusive entities or as inclusive. By specifically asking students to consider links, we acknowledged and implicitly inferred that relationships may exist; the research questions were – can students identify those relationships and in what ways
do they construct any “common ground” or “bridge”. We were aware that how students perceive these conceptions is shaped by number of factors: cultural socialization, school science and personal worldview. Due to limited time and access to students, we were unable to assess the factors that influenced their sense-making. We agree with Lee, Spencer, and Harpalani’s (2003) contention that there are no cultureless or neutral perspectives. Extending that to science, science is not acultural. By examining student perceptions we assessed whether there is a Eurocentric bias and if students explained cultural knowledge in conventional science terms. We studied the presence and characteristics of student connections, and assessed the ways they elaborated on similarities and differences between the two conceptions.

2.3 Methods

An exploratory case study approach was used in this research to gain insight into students’ understanding (Yin, 2003). The justification for using this methodology is that it appropriately provided a deep understanding of the complex phenomena of science and cultural knowledge. Case studies provide rich contextual data that “confirm, challenge, or extend the theory” (Yin, 2003, p. 40). Both literal and theoretical replication were used in the purposive sampling of the schools. Literal replication involved choosing cases that are similar and should achieve similar results (for example two Aboriginal school groups); theoretical sampling was used when theoretical assumptions were used to predict cases which might have contrasting results (for example a multicultural school group compared to an Aboriginal school group) or similar results (for example multicultural schools from Australia and from Malawi) (Yin, 2003).

2.3.1 Study participants

Convenience and purposive sampling (Phua, 2003) identified seven schools, six from Western Australia and one from Malawi (Table 2.1). Student year level ranged from Year 7-9 (ages 12-15). Purposive sampling was used because Aboriginal people (3.8% of the Western Australian population) are hard to access for research (Australian Bureau of Statistics, 2008; Given, 2008). There is a widely held view within Aboriginal communities that they are over-researched and are treated like objects of research rather than participants. This holds true in certain disciplines like psychology, crime, health,
anthropology and education (Martin & Mirraboopa, 2003). As a consequence, Aboriginal communities do not readily consent to participate in research. Purposive sampling was used to identify Aboriginal students, who are affiliated with one of the research project partners, the Graham Polly Farmer Foundation. The Graham Polly Farmer Foundation runs the Follow the Dream after school homework program for aspiring Aboriginal students. Pseudonyms are used in naming schools. Both School Maroon and School Quandong run the Follow the Dream program. Through the program, Aboriginal students are provided with one to one tutoring, enrichment activities and excursions that support personal and academic development.

School Maroon is a metropolitan school located less than 100 km from Western Australia’s capital city, Perth. The school has a focus on academic, personal and cultural development. The school’s co-location with tertiary institutions enables Aboriginal students in the Follow the Dream program to engage in vocational and industry related training. School Quandong is located in a mining town. Mining activity has led to rapid population growth and a diversity of cultures living in the area but the school maintains a large cohort of Aboriginal students (37%; \( n = 237 \) in 2011). While School Quandong has a rapid turnover of science teachers, the Follow the Dream program at this site has been successful in increasing the number of Aboriginal students who complete secondary school and go on to tertiary education or vocational training.

School Magenta is a large (\( N = 1,400 \)) high school that draws intake from both Schools Rainbow and Brown and has a large cohort of multicultural students. The school is considered one of the premier independent high schools in the state and offers a range of specialist programs tailored to students’ needs.

School Nyasa in Malawi is comparable to Western Australian independent schools. School Nyasa is a small (\( N = 90, 2011 \)) private boarding and day high school located in one of Malawi’s regional centres. The school was established in 2010, as a premiere international academy of excellence for the region. The school follows the University of Cambridge International General Certificate of Education (IGCSE) curriculum and science in Year 9 is taught using British Key Stage 3 textbooks and modules. The school employs teachers from Europe and America as well as Malawian teachers who have taught at prestigious international schools.
### Table 2-1
Description of study participants and data collected. School groups are in Western Australia except for School Nyasa.

<table>
<thead>
<tr>
<th>School</th>
<th>Description</th>
<th>Number of students</th>
<th>Year level</th>
<th>Number of group meaning maps</th>
<th>Ancestries</th>
</tr>
</thead>
<tbody>
<tr>
<td>School</td>
<td>Quandong</td>
<td>GPFF regional</td>
<td>18</td>
<td>Yr 7-9</td>
<td>Aboriginal, Australian, German, Irish, New Zealander</td>
</tr>
<tr>
<td>School</td>
<td>Maroon</td>
<td>GPFF metropolitan</td>
<td>8</td>
<td>Yr 8-12</td>
<td>Aboriginal, Australian, English, Irish, New Zealander</td>
</tr>
<tr>
<td>School</td>
<td>Magenta 1</td>
<td>Metropolitan</td>
<td>28</td>
<td>Yr 9</td>
<td>Australian, Burmese (Myanmar), Chinese, Hong Konger, Indian, Korean Republic, Malaysian, Mauritian, Mexican, Nepalese, Pilipino, Singaporean, Serbian, Taiwanese</td>
</tr>
<tr>
<td>School</td>
<td>Magenta 2</td>
<td>Metropolitan</td>
<td>24</td>
<td>Yr 9</td>
<td>Australian, Chinese, Ethiopian, Ghanaian, Singaporean, Malaysian</td>
</tr>
<tr>
<td>School</td>
<td>Nyasa</td>
<td>Malawi regional</td>
<td>21</td>
<td>Yr 9</td>
<td>Malawian, Indian, Iranian, Pakistani, Zimbabwean</td>
</tr>
<tr>
<td>School</td>
<td>Rainbow</td>
<td>Metropolitan</td>
<td>30</td>
<td>Yr 7</td>
<td>Aboriginal, Australian, English, Ethiopian, Japanese, Kenyan, Libyan, Malaysian, New Zealander, Romanian, Serbian, South African, Thai, Ukrainian</td>
</tr>
<tr>
<td>School</td>
<td>Brown</td>
<td>Metropolitan</td>
<td>38</td>
<td>Yr 7</td>
<td>Aboriginal, Australian, Chinese, Dutch, Greek, Indian</td>
</tr>
<tr>
<td>School</td>
<td>Cyan</td>
<td>Metropolitan</td>
<td>25</td>
<td>Yr 7</td>
<td>Aboriginal, Australian, American, Chinese, Dutch, Eastern Block, Italian, Irish, Jewish, Singaporean</td>
</tr>
</tbody>
</table>

| Total     | 190               | 45                 |

GPFF = Graham Polly Farmer Foundation, Year 7= 12-13 years, Year 8= 13-14 years, Year 9= 14-15 years
The inclusion of a comparable Malawian school enabled us to explore how indigenous students in another country who are taught using a western curriculum view the interface between science and cultural knowledge; this adds depth to our discussions of Australian Aboriginal students and students from other cultural perspectives.

School Rainbow is a co-educational primary school in the state’s capital, Perth. The school has a large cohort of students from different cultural backgrounds. In 2011, 42% \( (n = 155) \) of the students at the school spoke a language other than English at home. The school has a mixture of students from various socio-economic backgrounds including middle and upper incomes and refugees from around the world. School Brown is also a co-educational primary school with a similar mix of multicultural students and is located in a suburb close to School Rainbow. School Cyan, a government primary school, is located in a more affluent suburb. School Cyan and School Brown have smaller African and Asian demographics compared to School Rainbow. School Brown and School Rainbow have a similar philosophy of embracing cultural diversity.

The inclusion of multicultural metropolitan school groups and a comparative Malawian school provided rich qualitative information. Having students from different cultures – (Table 2.1) added richness to the data and enabled us to explore intercultural understanding. We do not generalize from our research but put forward a descriptive analysis (Creswell, 2008; Maxwell, 2004); therefore it was justifiable to use a diverse mix of schools groups, including the Malawian school.

2.3.2 Ethics approval

Separate applications were submitted and approved by the University of Western Australia Human Ethics Committee (RA/4/1/4434) and the Western Australian Department of Education. Participant consent was sought from principals, parents and students at all schools in Australia and in Malawi. Every effort was made to conduct the research in accordance with the values and ethics of Aboriginal and Torres Strait Islander Research (National Health and Medical Research Council, 2003).

2.3.3 Tool

An adaptation of personal meaning maps, group meaning maps, was used in this study to collect student perceptions. Personal meaning maps are similar to mind maps in that
they present a hierarchical overview of ideas emanating from a central concept (Eppler, 2006). Personal meaning maps require students to write on a blank sheet of paper as many words, images, phrases, or thoughts related to a particular word or phrase as possible. Colour and drawings are often used in mind maps to illustrate several ideas and to aid recall for visual learners. Personal meaning maps differ from mind maps in that they allow people to articulate and negotiate their perceptions, emotional disposition and understandings in their own words from their own cognitive frame of reference; there is no correct answer. Personal meaning maps encourage students to draw on prior experiences, interactions, knowledge of word meanings and word identifications. Cultural (indigenous) knowledge is a term that is ambiguously used; considering the emphasis in the Australian curriculum on Intercultural understanding it was important to determine students’ understanding of this term.

A survey was avoided as multiple choice, Likert scale instruments can force students to position their responses in alignment with researchers’ views which may or may not align with their own views. Few validated instruments exist that examine students’ interpretation of indigenous knowledge within the context of science such as Aikenhead’s Views on Science-Technology-Society (VOSTS) (Aikenhead & Ryan, 1992). Aikenhead’s rationale for developing VOSTS was to overcome students’ misinterpretation of ambiguous statements. Although VOSTS has been adapted, redeveloped and used in numerous contexts, Lederman et al. (2002) and Rubba and Harkness (1996) have written at length on the poor validity of standardized paper and pencil tests to assess learners’ perceptions. These instruments assume that respondents understand statements in the same manner as researchers and the instruments reflect the biases and views of the researcher. Lederman et al. (2002) also contend that standardized instruments are useful for collecting large data sets but only to the extent of labelling students’ views on the nature of science as adequate or inadequate. We also note that researchers have observed that Malawian students’ questionnaire responses may suffer from social desirability bias (Dzama, et al., 2008; Phiri, 2008).

Group meaning maps were chosen as they elicit free responses from students, thus encouraging creativity and self-expression and overcome some of the concerns of pen and pencil instruments raised by Lederman et al. (2002) and social desirability response bias (Dzama, et al., 2008). Use of group meaning maps is learnt easily and can engage students with varying literacy skills. Group meaning maps provide quantitative and
qualitative measures of attitudes, personal conceptions, and to a certain extent emotional domains.

Three parameters that can be analysed from group meaning maps are extent, breadth and depth. The extent of each person’s awareness and understanding of both scientific and cultural knowledge was analysed by looking at the vocabulary used to discuss the two concepts. Falk and Storksdieck (2005) write that the “extent thus measures the most basic aspect of an individual’s understanding of a concept or topic, the degree to which they can generate words to describe their understanding” (p. 752). The second parameter, breadth of understanding, involves how widely or narrowly the student understands scientific and cultural knowledge. “Breadth, thus, measures a fundamental aspect of learning that an idea or phenomenon can be understood in more than one way” (Falk & Storksdieck, 2005, p. 753). And finally, the depth of students’ understanding examined how deeply and richly students understand and make connections between scientific and cultural knowledge. “Depth measures the changes in degree of understanding within each breadth category and is therefore a measure of conceptual understanding” (Falk & Storksdieck, 2005, p. 753). To a limited extent emotional looking at the vocabulary can assess sensitivity and emotional descriptors used that may convey students’ attitudes towards scientific and cultural knowledge.

A pilot phase was conducted with two school groups – one Aboriginal group from a regional Graham Polly Farmer Foundation program and the other a metropolitan school with a heterogeneous group of students. In the pilot phase, personal meaning maps were used and each student was asked to write on a single piece of paper the ideas they associated in one domain on cultural knowledge and in another domain on scientific knowledge and, if possible, to link the two domains. This was followed by a science and culture story box activity (Chapter 3 and (Gondwe & Longnecker, 2011). After the activity, students were invited to make adjustments to their personal meaning maps. The personal meaning maps from the pilot study yielded poor results – few students revised their personal meaning maps in the post activity and a number of personal meaning maps were returned without any writing or had incomprehensible scribbles. In consultation with four science education researchers, the personal meaning map exercise was revised to a small group (four students) activity and the post activity was abandoned. The use of group meaning maps presents limitations to our findings in that firstly, in a group setting students may feel uncomfortable in voicing their opinions.
Secondly, it is not possible to associate any particular map to an individual. Thirdly, one group member may dominate. However, the rich results from the group meaning maps compared to the poor results from personal meaning maps outweighed the limitations of using this methodology.

As noted in the introduction, the definitions of cultural knowledge and science are controversial. Perhaps even more controversial is to ask students to assign meaning to “cultural knowledge and scientific knowledge” as though disparate conceptions, as was done in this study. The lack of consensus in the literature on terminology will cause any research in this area to have inherent difficulties but we believe that the value of the research results outweighs the possible confusion. Initially ‘science’ and ‘culture’ were chosen as the terms but after testing these conceptions with the Science Communication Research Group at The University of Western Australia, it was agreed that these conceptions were too broad. Looking specifically at ‘knowledge’ focuses thinking and separating scientific knowledge and cultural knowledge allows students to consider relationships between the two domains. We note that the word knowledge does not translate well into indigenous languages as a noun but as a verb referring to coming to know. Unlike indigenous knowledge, knowledge in the Eurocentric sense is something that can be owned, accumulated, assessed by pen and paper examination and can be separated from the knower (Aikenhead & Ogawa, 2007).

### 2.3.4 Data collection

All of the data were collected in 2011. Table 2.1 shows the number of schools and ancestries of participants and the data that were gathered. Students were asked to break into groups of four or five. The first author demonstrated, as part of a whole class exercise, how to develop a group meaning map with a number of extended branches and with domains that connect. Before conducting the group meaning map demonstration, students were asked by a show of hands if they were familiar with mind maps. In all but the Malawian school, most students had experience developing mind maps. Books and movies were used as the example conceptions. Books and movies were written on a large white board. The researcher then asked students “what comes to mind when you think of books and movies?” Students’ responses were written on the white board. For example, if students said actors, a line was drawn from movies-actors. The researcher then asked if anything else came to mind in relation to actors, students often called out
Harry Potter, then others would suggest this also related to books. Therefore, line connections would be drawn from movies-actors-Harry Potter-books. As students suggested more ideas the researcher would ask them to consider whether it linked to the central concept or was a branch of an existing concept; e.g. genre was an idea related to books and humour was a type of genre.

After the example, the two domains of scientific knowledge and cultural knowledge were written on the white board. Each group of four students was provided a large blank paper and markers. Groups were asked specifically “what comes to mind when you think of scientific knowledge and cultural knowledge and what, if any, are the connections between the two?” Groups were given 15 minutes to complete the exercise. An audio recorder was set up on one of the group’s desk to capture group discussion as they performed this activity. Data from this discussion and other activities carried out during these sessions address other research questions that will be reported elsewhere.

2.4 Data analysis

2.4.1 Quantitative analysis

Analysis was conducted between schools, across year groups and within schools. Specific comparisons were made between and across the Aboriginal groups, the multicultural student groups and years 7 and 9. Group responses were statistically analysed to examine the extent, breadth, depth of ideas in scientific knowledge, cultural knowledge and links between the two.

Extent was measured by counting the total number of ideas for each domain; breadth was measured by counting the number of first order ideas around the domain; and depth was measured by counting the hierarchies stemming from an idea. Depth was scored based on the number of levels on a branch with more extended branches given a higher weighting. An analogy to describe extent, breadth and depth is the structure of a tree. The extent of ideas is analogous to the number of leaves on a tree, the breadth is the number of scaffold branches and the depth is the number of linked lateral branches (Figures 2.1 and 2.2). Links were counted as the number of branches connecting the two domains.
Initial analysis of all groups’ written ideas on scientific knowledge \((n = 721)\) and cultural knowledge \((n = 662)\) and the connections between the two were conducted by transcribing the group meaning maps and inputting the text into Wordle.net to generate word clouds. Word clouds are text visualization in which more frequently cited words are given more prominence. Word clouds are a visually rich way to provide a preliminary analysis of the data (McNaught & Lam, 2010). However, Wordle.net software discriminates between plural and singular derivatives of the same word \((i.e.\, \text{discovery and discoveries are counted separately})\). Data were adjusted to correct spelling mistakes \((e.g.\, \text{trdations to traditions})\) and replace derivatives with the same word \((e.g.\, \text{all mentions of “traditional” and “tradition” to “traditions”})\).

2.4.1 Qualitative data analysis

Thematic coding was used to analyse groups’ responses (Krippendorff, 2004; Saldana, 2009). While the data were collected in 2011, the Australian 2012 science curriculum’s three interrelated strands: Science Understanding, Science as Human Endeavour and Science Inquiry Skills were used initially as categories in the coding manual. This approach was taken to enable discussion about how groups’ responses related to the science curriculum. However this proved problematic because a number of ideas overlapped \((e.g.\, \text{‘energy’ could be placed in Science Understanding as well as a Science as Human Endeavour})\). Secondly, the Australian Curriculum does not provide a suitable framework for assessment of groups’ responses in the cultural knowledge domain. Hidalgo’s three levels of culture: concrete \((\text{visible and tangible culture e.g. food})\), behavioural \((\text{a reflection of values e.g. gender roles})\) and symbolic \((\text{values and beliefs e.g. religion})\) were initially used for the cultural domain but to allow for meaningful comparisons between scientific knowledge and cultural knowledge, inductive themes were generated that could be used for both conceptions (Hidalgo, 1993).

The two authors came to coding with different understandings of culture and science which reflect our own cultural biases. For example Gondwe coded “philosophy” as a value while the Longnecker coded it as an attribute of science. Longnecker is a white American who migrated to Australia 26 years prior to the time of coding while Gondwe is from Malawi and had lived in Africa, the United Kingdom and the Caribbean as well as Australia for three years at the time of coding. Although the Gondwe is a native of Malawi, she has a western worldview and tertiary education in science. We therefore acknowledge that our interpretation occurs largely through a
western scientific lens. However we both hold that scientific and cultural knowledge systems have similarly produced intellectual satisfaction, spiritual gratification and material benefits through different methodical approaches.

Figure 2-1 Group meaning map with no links from School Magenta 2. Scientific knowledge ideas: extent=20, breadth=20, depth=0. Cultural knowledge ideas: extent=10, breadth=10, depth=0.

Figure 2-2 Group meaning map with links from School Brown. Scientific knowledge ideas: extent=19, breadth=14, depth=0. Cultural knowledge ideas: extent=23, breadth=18, depth=2.
The development of a validated coding manual involved an iterative process between both authors. Our differences yielded provocative and extended conversations and negotiations; development of a robust coding manual required four iterations. While there was consistent agreement on coding the scientific domain, coding in the cultural domain produced inconsistent results. One of the group meaning maps had “theory” as an idea in a link. In one of the versions of the coding manual there was a category under cultural knowledge labelled ‘relates to science’. One researcher coded “theory” under cultural knowledge as relates to science while the other coded it in explanation and understanding.

The category “relates to science” was proposed as a category to capture ideas like “DNA” and “energy”. After deliberating the potential western science bias that this category imposed on cultural knowledge and following repeated discussions and failed attempts to code consistently using complex categories, simple categories were generated with one to one mapping of each category across domains to avoid bias (Table 2.2).

Using the simplified coding manual, initial intercoder agreement was 87% for scientific knowledge and 77% for cultural knowledge. Identity was added to Category D – beliefs, values and attitudes to include personal characteristics. Category B – knowledge & understanding refers to facts and information. The definition for knowledge & understanding was revised for cultural knowledge and was broadened to include concepts and themes. A representative sample of 10% (5 group meaning maps) from different school groups and with varying levels of link complexity was chosen for testing of intercoder agreement. A researcher in the same group but who had not been involved with this research project was provided with the manual and coded independently without consultation or guidance (Lombard, Snyder-Duch, & Bracken, 2004). The final intercoder agreement was 90.4% for scientific knowledge and 85.2% for cultural knowledge.

SPSS (version 21) was used for statistical analysis of coded responses. Values were calculated for skewness, kurtosis and Kolmogorov-Smirnov statistic for cultural knowledge (skewness=1.794, kurtosis=6.438 and Kolmogorov-Smirnov statistic p=.198) and scientific knowledge (skewness=1.528, kurtosis=.191 and Kolmogorov-Smirnov statistic p=.025). Although the Kolmogorov-Smirnov statistic for cultural knowledge
Table 2-2  
Coding manual developed for thematic coding of group meaning maps produced by small groups of four students asked to produce words relating to the constructs, scientific knowledge and cultural knowledge.

<table>
<thead>
<tr>
<th>Category response</th>
<th>Description of category</th>
<th>Example of category</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scientific knowledge</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A Skills and processes refers to the process of and tools used for acquiring scientific knowledge.</td>
<td>Microscope</td>
<td>Hypothesis</td>
</tr>
<tr>
<td></td>
<td>Investigation</td>
<td>Variables</td>
</tr>
<tr>
<td></td>
<td>Experiments</td>
<td>Calculation</td>
</tr>
<tr>
<td>B Knowledge and understanding refers to concepts, themes, principles in any science subject.</td>
<td>History</td>
<td>Biology</td>
</tr>
<tr>
<td></td>
<td>Gravity</td>
<td>Molecules</td>
</tr>
<tr>
<td></td>
<td>Einstein</td>
<td>Rockets</td>
</tr>
<tr>
<td>C Applications refers to the application of science or products developed out of science and technology</td>
<td>Medicine</td>
<td>Discoveries</td>
</tr>
<tr>
<td></td>
<td>3 Bridges</td>
<td>Plants</td>
</tr>
<tr>
<td></td>
<td>Dam</td>
<td>Animal</td>
</tr>
<tr>
<td>D Values, Attitudes, Beliefs and Identity refers to ways of thinking, opinions, judgements and personal characteristics.</td>
<td>Creativity</td>
<td>God</td>
</tr>
<tr>
<td></td>
<td>Intelligence</td>
<td>Scientists</td>
</tr>
<tr>
<td></td>
<td>Nerds</td>
<td>Myths</td>
</tr>
<tr>
<td>E Other</td>
<td>does not fit in any of the above categories.</td>
<td>Cowboys</td>
</tr>
<tr>
<td>F Nonsense</td>
<td>doesn’t make sense to coders.</td>
<td>Dre</td>
</tr>
<tr>
<td>G Bob</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cultural knowledge</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A Skills and processes refers to the process of and tools used for enacting culture.</td>
<td>Dance</td>
<td>Language</td>
</tr>
<tr>
<td></td>
<td>Music</td>
<td>Study</td>
</tr>
<tr>
<td></td>
<td>Celebration</td>
<td>Festivals</td>
</tr>
<tr>
<td>B Knowledge and understanding refers to concepts and themes of culture including physical objects (not specifically related to festivals and celebrations) that represent culture.</td>
<td>History</td>
<td>Age</td>
</tr>
<tr>
<td></td>
<td>Clothes</td>
<td>Community</td>
</tr>
<tr>
<td></td>
<td>Home</td>
<td>Aboriginal</td>
</tr>
<tr>
<td>C Applications refers to the application of science or products developed out of science and technology or culture.</td>
<td>Medicine</td>
<td>Religion</td>
</tr>
<tr>
<td></td>
<td>Boomerang</td>
<td>Dreamtime</td>
</tr>
<tr>
<td>D Values, Attitudes, Beliefs and Identity refers to ways of thinking, opinions, judgements and personal characteristics.</td>
<td>Religion</td>
<td>Accent</td>
</tr>
<tr>
<td></td>
<td>Dreamtime</td>
<td>Skin colour</td>
</tr>
<tr>
<td></td>
<td>God</td>
<td>Friends</td>
</tr>
<tr>
<td></td>
<td>Ancestors</td>
<td>Family</td>
</tr>
<tr>
<td></td>
<td>Cowboys</td>
<td>World Vision</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Evolution</td>
</tr>
<tr>
<td>E Other</td>
<td>does not fit in any of the above categories.</td>
<td>Cowboys</td>
</tr>
<tr>
<td>F Nonsense</td>
<td>doesn’t make sense to coders.</td>
<td>Bob</td>
</tr>
</tbody>
</table>

43
suggests normality, based on the kurtosis and skewness scores the group meaning map data did not conform to normality (Pallant, 2010) and so descriptive and non-parametric statistical tests were used to analyse the coded responses. The influence of extreme outliers was assessed by comparing the five percent trimmed mean with the mean value for scientific knowledge and cultural knowledge (Pallant, 2010). The difference in the five percent trimmed mean for scientific knowledge (15.71) and the mean (16.20) and for cultural knowledge five percent trimmed mean (14.74) and the mean (15.38) suggests little influence of outliers on the overall mean and it was decided to include outliers in the analysis (Pallant, 2010).

The differences in medians of links, depth, extent and breadth of ideas between and across schools was assessed by Kruskal-Wallis tests. The Kruskal-Wallis tests were also used to analyse differences in the four coded main categories across the seven schools. Statistical significance of differences in results was further investigated with post-hoc Mann-Whitney U tests to determine where the differences lay (Field, 2009).

2.4.2 Methodological limitations

Group meaning maps may not authentically represent groups’ entire understanding of complex phenomena but can provide a glimpse into student perceptions. As with pencil and paper instruments, group meaning maps are subject to bias. Scientific knowledge and cultural knowledge are complex domains and we do not intend to trivialize or oversimplify them by using group meaning maps or by the way we have analysed the data. Our analysis treats each idea as having equal weight. We believe this to be a fair approximation because this is an exploratory study seeking to characterize and not assess students’ understanding. Analysis of student ideas in the absence of interviews to verify can lead to researcher bias or imprinting researchers’ views on student understanding. Care was taken in developing the coding manual so as not to add a layer of westernized compartmentalization and also by using categories that encapsulated ideas in both scientific knowledge and cultural knowledge (e.g. values, beliefs and attitudes).

2.5 Results

The words that students included in their group meaning maps were transcribed and presented as word clouds. Words relating to scientific knowledge are shown in Figure
2.3 and cultural knowledge in Figure 2.4. The larger the word in the word cloud, the more often it or its derivates were mentioned in group meaning maps.

Out of 45 group meaning maps, the top three most cited ideas for scientific knowledge were experiments \((n = 21)\), followed by physics \((n = 12)\) and then animals \((n = 11)\) (Figure 2.3). For cultural knowledge, out of 45 group meaning maps, the top three most cited ideas were religion \((n = 23)\), food \((n = 20)\) and language \((n = 16)\) (Figure 2.4).

2.5.1 Extent of scientific knowledge and cultural knowledge

There were differences in the extent of cultural knowledge presented by groups in different schools but no differences in extent of scientific knowledge (Tables 2.3 and 2.4). Groups from School Maroon (Aboriginal group) presented the greatest extent
(total number) of cultural knowledge ideas in their group meaning maps (Md=22.50) followed by School Nyasa (Malawi, Md=18.50). Groups from School Brown had the lowest score for extent of cultural knowledge ideas (Md=8.50). There were no significant differences in the extent or total number of scientific knowledge ideas provided by groups in the different schools (Kruskal-Wallis test, Table 2.4).

Table 2-3
School group medians for links, extent, breadth and depth of words provided in group meaning maps about the constructs of scientific knowledge (SK) and cultural knowledge (CK) produced by small groups of four students in different schools.

<table>
<thead>
<tr>
<th>School</th>
<th>Links</th>
<th>Extent</th>
<th>SK</th>
<th>CK</th>
<th>Breadth</th>
<th>SK</th>
<th>CK</th>
<th>Depth</th>
<th>SK</th>
<th>CK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quandong (n=4)</td>
<td>1.5</td>
<td>12.0</td>
<td>12.0</td>
<td>6.0</td>
<td>6.5</td>
<td>5.0</td>
<td>8.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maroon (n=2)</td>
<td>0.0</td>
<td>15.5</td>
<td>22.5</td>
<td>15.0</td>
<td>17.5</td>
<td>0.0</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magenta 1 (n=6)</td>
<td>10.5</td>
<td>18.5</td>
<td>16.5</td>
<td>16.5</td>
<td>13.0</td>
<td>0.0</td>
<td>0.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magenta 2 (n=6)</td>
<td>2.5</td>
<td>11.5</td>
<td>11.5</td>
<td>9.5</td>
<td>7.0</td>
<td>0.0</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nyasa (n=4)</td>
<td>6.5</td>
<td>18.5</td>
<td>18.5</td>
<td>11.0</td>
<td>9.5</td>
<td>4.5</td>
<td>4.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rainbow (n=7)</td>
<td>3.0</td>
<td>18.0</td>
<td>18.0</td>
<td>11.0</td>
<td>12.0</td>
<td>0.0</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brown (n=6)</td>
<td>3.5</td>
<td>11.5</td>
<td>8.5</td>
<td>6.5</td>
<td>5.0</td>
<td>0.0</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyan (n=10)</td>
<td>2.0</td>
<td>16.0</td>
<td>16.0</td>
<td>14.0</td>
<td>9.5</td>
<td>0.0</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median score</td>
<td>3.0</td>
<td>15.0</td>
<td>14.0</td>
<td>10.0</td>
<td>9.0</td>
<td>0.0</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No shading = Aboriginal school groups, Dark grey = Year 9, Light gray=Primary schools, (n = number of group meaning maps)

Table 2-4
Extent (total number) of cultural knowledge and scientific knowledge ideas compared across schools using Kruskal-Wallis tests.

<table>
<thead>
<tr>
<th>Extent of ideas</th>
<th>df</th>
<th>n</th>
<th>$\chi^2$</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>scientific knowledge ideas</td>
<td>7</td>
<td>45</td>
<td>11.246</td>
<td>.128</td>
</tr>
<tr>
<td>cultural knowledge ideas</td>
<td>7</td>
<td>45</td>
<td>15.825</td>
<td>.027*</td>
</tr>
</tbody>
</table>

* p < .05, ** p < .01

2.5.2 Breadth of scientific knowledge and cultural knowledge

There were large differences between schools in the breadth of both scientific knowledge and cultural knowledge ideas produced in the group meaning maps (Tables 2.3 and 2.5). Groups from School Magenta 1 had the widest breadth of scientific knowledge ideas (Md=16.50), whilst students from School Quandong had the narrowest breadth of scientific knowledge ideas (Md=6.00). Groups from School Maroon had the
widest breadth of cultural knowledge ideas ($Md=17.50$), whilst groups from School Brown had the narrowest breadth of cultural knowledge ideas ($Md=5$) (Table 2.3).

Table 2-5

<table>
<thead>
<tr>
<th>Breadth of ideas</th>
<th>df</th>
<th>n</th>
<th>$\chi^2$</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>scientific knowledge ideas</td>
<td>7</td>
<td>45</td>
<td>14.476</td>
<td>.043*</td>
</tr>
<tr>
<td>cultural knowledge ideas</td>
<td>7</td>
<td>45</td>
<td>21.631</td>
<td>.003*</td>
</tr>
</tbody>
</table>

* $p < .05$, ** $p < .01$

2.5.3 Depth of scientific knowledge and cultural knowledge

There were significant differences in the depth of ideas of scientific knowledge and cultural knowledge provided by groups from the different schools (Tables 2.3 and 2.6). Groups from School Quandong presented greater depth of ideas for both scientific knowledge ($Md=5.00$) and cultural knowledge ($Md=8.50$) (Table 2.3). This was followed by School Nyasa (Malawi $Md=4.5$ for scientific knowledge and $Md=4.5$ for cultural knowledge). A number of school groups did not register any depth for scientific and cultural knowledge ideas (Magenta 2, Rainbow, Brown, Cyan). Those groups with the lowest depth of ideas provided by students in their group meaning maps tended to be Year 7 groups.

Table 2-6

<table>
<thead>
<tr>
<th>Depth of ideas</th>
<th>df</th>
<th>n</th>
<th>$\chi^2$</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>scientific knowledge ideas</td>
<td>7</td>
<td>45</td>
<td>15.973</td>
<td>.025*</td>
</tr>
<tr>
<td>cultural knowledge ideas</td>
<td>7</td>
<td>45</td>
<td>24.084</td>
<td>.001**</td>
</tr>
</tbody>
</table>

* $p < .05$, ** $p < .01$

2.5.4 Links between scientific knowledge and cultural knowledge

There were significant differences ($p=.016$) in the number of links provided by groups from different schools (Table 2.3). Groups from School Magenta 1 presented the highest number of links between scientific and cultural knowledge ($Md=10.50$) whilst neither group from School Maroon presented any links ($Md=0.00$). The ideas most cited
in linking scientific knowledge to cultural knowledge were history \((n = 7)\), food \((n = 7)\),
animals \((n = 5)\), music \((n = 5)\), art \((n = 5)\) and religion \((n = 5)\) (Figure 2.5).

**Figure 2-5 Links between scientific knowledge and cultural knowledge word cloud for group ideas \((n = 195)\) generated in group meaning maps.**

### 2.5.5 Thematic analysis

Words used by students in the group meaning maps were coded into four themes as presented in Table 2.2. Figure 2.6 presents the percent response in the different thematic areas for each knowledge domain. Groups provided more words in the thematic area *knowledge & understanding* for both scientific knowledge \((M_d=9.00)\) and cultural knowledge \((M_d=7.00)\), followed by *values, attitudes, beliefs & identity* for cultural knowledge \((M_d=3.00)\) and then *skills & processes* for both scientific knowledge \((M_d=2.00)\) and cultural knowledge \((M_d=2.00)\). The results of the Friedman’s Test of the different themes indicated that there were significant differences in groups’ responses across the themes \((\chi^2(7, n = 45)=159.470, p<.005)\).

Significant differences were found across the schools for the themes *skills & processes* and *knowledge & understanding* for cultural knowledge, and *values, attitudes, beliefs & identity* for scientific knowledge (Table 2.7).

Further analysis of the cultural knowledge ideas for the thematic categories to quantify the number of Aboriginal specific examples (e.g. “boomerang”, “didgeridoo”), versus non-Aboriginal specific examples (e.g. “Jesus”, “Greek”) revealed the ratio of
Aboriginal to non-Aboriginal examples for skills and processing was 9:1, for knowledge & understanding was 24:1, applications was 3:0, and for values, attitudes, beliefs and identity was 0.93:1.

Figure 2-6 Percentage of words from group meaning maps coded into different themes for scientific knowledge (n = 721) and cultural knowledge (n = 686).

Table 2-7
Themes in both cultural knowledge and scientific knowledge domains compared across schools using Kruskal-Wallis tests.

<table>
<thead>
<tr>
<th>Themes</th>
<th>df</th>
<th>n</th>
<th>$\chi^2$</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skills &amp; processes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>scientific knowledge</td>
<td>7</td>
<td>45</td>
<td>13.137</td>
<td>.069</td>
</tr>
<tr>
<td>cultural knowledge</td>
<td>7</td>
<td>45</td>
<td>14.510</td>
<td>.043*</td>
</tr>
<tr>
<td>Knowledge &amp; understanding</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>scientific knowledge</td>
<td>7</td>
<td>45</td>
<td>10.844</td>
<td>.146</td>
</tr>
<tr>
<td>cultural knowledge</td>
<td>7</td>
<td>45</td>
<td>14.163</td>
<td>.048*</td>
</tr>
<tr>
<td>Applications</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>scientific knowledge</td>
<td>7</td>
<td>45</td>
<td>11.844</td>
<td>.106</td>
</tr>
<tr>
<td>cultural knowledge</td>
<td>7</td>
<td>45</td>
<td>10.880</td>
<td>.144</td>
</tr>
<tr>
<td>Values, attitudes, beliefs &amp; identity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>scientific knowledge</td>
<td>7</td>
<td>45</td>
<td>21.594</td>
<td>.003**</td>
</tr>
<tr>
<td>cultural knowledge</td>
<td>7</td>
<td>45</td>
<td>12.665</td>
<td>.081</td>
</tr>
</tbody>
</table>

* p < .05, ** p < .005
Thematic coding of the ideas for links revealed that of the 163 links which used 232 ideas, 48% \((n = 111)\) fit under the *knowledge & understanding* theme (Table 2.2), followed by 24% \((n = 55)\) under *skills & processes*, 21% \((n = 49)\) under *values, attitudes, belief and identity* and 7% \((n = 17)\) under *applications*.

### 2.6 Discussion

#### 2.6.1 Differences in scientific knowledge and cultural knowledge

There were no significant differences in extent of scientific knowledge ideas across schools but there were differences in extent of cultural knowledge ideas across schools (Table 2.4). Year 9 groups who have had more years of science education did not cite significantly greater number of scientific knowledge ideas than primary school groups, Malawian or Aboriginal groups (Tables 2.3 and 2.4). School Rainbow, a primary school group, had a high median score for scientific knowledge compared to the other primary school groups and some of the secondary school groups (Table 2.3). School Rainbow had a specialist science teacher who has been a recipient of a Science Educator of the Year award for using innovative strategies like cartoons and puppets to engage her students, designing activities to develop and build on students’ knowledge across the years and planning lessons that draw on students’ needs, cultural background and different learning styles. Groups from School Rainbow also has higher median score for cultural knowledge than the other primary schools. Thematic analysis of scientific knowledge ideas expressed by groups from School Rainbow revealed that the ideas were mainly within the *knowledge & understanding* theme, i.e. mainly scientific facts and content information.

The Aboriginal groups of students scored the highest for depth and breadth of ideas for cultural knowledge. School Maroon, an Aboriginal group, scored the highest of all the school groups for extent of cultural knowledge ideas. They also scored quite highly for breadth of ideas for both knowledge domains. The Graham Polly Farmer Foundation’s main focus is on school performance and homework but program coordinators also run extension activities on Aboriginal culture, self esteem and confidence. It is possible that these extension activities as well as all students coming from an Aboriginal background gave students a wealth of knowledge which they could draw on for Aboriginal examples. The thematic responses for both Aboriginal groups for cultural knowledge
were mainly in the themes *knowledge & understanding* and *values, attitudes, belief & identity*. Aboriginal culture places a strong emphasis on family, connection to country or land and The Dreamtime. This is exemplified in the ideas that students from the Aboriginal groups presented as examples, including “relatives-family”, “Dreamtime story”, “women’s and men’s role”. The Dreamtime or the Dreaming refers to a sacred period in which ancestral totemic spiritual beings created the world. The Dreaming is the basis of Aboriginal people’s beliefs and spirituality. Different Aboriginal groups across Australia have different Dreamings. Dreamtime stories, the Dreaming and specific totemic spirits such as the “Rainbow snake” were also mentioned by other school groups.

There were mentions of “scientific explosions” or “bombs” which are common activities used to excite students with the wonders of science during informal science education incursions or excursions (Stocklmayer & Gilbert, 2003). A few of the group meaning maps mentioned racism and the Stolen Generation. Only in School Magenta 2 did students produce a number of group meaning maps that described both knowledge domains as “ways of understanding the world”. This suggests that this concept may have been taught to students in class. The highest number of links between cultural and scientific knowledge were found in four groups from School Magenta 2. This finding suggests that cultural knowledge may have been specifically taught in the context of science at school. Students from this school also reported the greatest number of ideas in the theme *values, attitudes beliefs & identity* (e.g. “offer explanations”, “beliefs don’t change-people’s interpretation changes”, “myths”, “legends and superstitions”). These ideas relate to worldview (Cobern, 1996).

A number of student groups juxtaposed scientific knowledge as “intelligence”, “genius”, “lab coat” and “advanced knowledge” against cultural knowledge as “basic knowledge”, “ancient formulas” and “history”. This exposes student perception of a dichotomy of scientific knowledge as being more important and more valid compared to cultural knowledge which students may perceive as static and ancient. For multicultural education, students should be made aware of how cultural knowledge informs science and that cultural knowledge is a valid, living and dynamic way of knowing. Environment was one of the ideas groups listed as a link between scientific and cultural knowledge, providing a logical topic for discussion of the role of both in development of understanding the natural world. There are a number of Australian examples of
research in ecology and environment that present opportunities to engage students with connections between scientific and cultural knowledge (Horstman & Wightman, 2001; Hunting, 2000; Russell-Smith, et al., 1997).

2.6.2 Embracing other cultural knowledges

In the Australian schools, examples from Aboriginal culture were more prevalent than non-Aboriginal examples; this is important considering the founding status of Aboriginal and Torres Strait Islanders. However, considering that a majority of students from the metropolitan schools in this study were either born overseas or had one parent born overseas (Table 2.1) we expected to see more examples from other cultures. The word Aboriginal was mentioned in 11 of the 41 Australian group meaning maps suggesting Australian students commonly make an association between Aboriginal culture and cultural knowledge. Values, attitudes, beliefs & identity was the only theme in which groups drew on examples from other cultures and these examples were mostly associated with religion as groups provided words like “Jesus”, “The Bible” and “Buddha”. Cultural knowledge was chosen as the subject title for the group meaning maps, instead of indigenous knowledge because in Australia, indigenous knowledge is closely associated with Aboriginal knowledge. It also appears from the group meaning maps and in discussions with students following the exercise that students are unaware of the culture of science and that aside from Aboriginal culture, they do not have a concept of an Australian culture. The lack of examples from other cultures may either suggest that students still associate cultural knowledge with Aboriginal knowledge or that if unprompted, students are unable to identify other types of cultural knowledge. Aboriginal culture is given prominence in the Australian curriculum and this may be at the expense of not validating or legitimizing other cultures in the science classroom. A number of scholars have written about the value of multidimensional multicultural education in promoting equitable access, academic achievement for all students and preparing students to be productive citizens (Banks & Banks, 2009; Gay, 2003; Ladson-Billings, 1995).

2.6.3 Common ground

None of the Aboriginal groups made many links between scientific knowledge and cultural knowledge, despite having a greater extent and breadth of ideas for both knowledge domains. The groups from School Maroon, a metropolitan Aboriginal after
school program, provided no links between scientific knowledge and cultural knowledge (Table 2.3). Using Aikenhead’s (1996) terminology, these students may experience hazardous border crossings where they don’t see any connections between their everyday life and the science they learn in the classroom. For indigenous students, learning science can be considered a type of trans-cultural learning experience and some students reject this assimilation into a foreign culture. This is thought to be partially responsible for the gap in science education outcomes between Aboriginal and non-Indigenous students (Woods-McConney, et al., 2011). The links from the group meaning maps can be considered a third space, bridge or common ground, which can help students navigate between their everyday world and the science classroom. The links provide a mental bridge on which to engage students in science learning and demonstrate how cultural knowledge and science can complement each other in students’ everyday experiences.

In contrast with the Australian groups, the Malawian school groups provided a number of links. An analysis of their links show that the Malawian students in this study used scientific knowledge to validate their everyday life worlds. For example the Malawian student groups linked scientific knowledge to cultural knowledge through “chemical reactions to cooking”, “energy to sound” and “singing” and “biological control to farming”. Other school groups did not have such complex explanatory links. In Malawian students’ group meaning maps “walking”, “singing”, “dancing”, “farming” and “cooking” were frequently found connected to cultural knowledge. This suggests that for these students cultural knowledge includes their everyday life worlds, their daily activities and practices. These Malawian students’ ability to identify science in their everyday life suggests a smooth border crossing where scientific and cultural knowledge can coexist and interact (Aikenhead & Jegede, 1999). For one year, these students had a youthful, dynamic British science teacher who would take them outdoors for some of their science lessons. She would find examples in the local environment even though the students were learning the British Key Stage 3 Science. It is possible that these explicit demonstrations of science in their own environment enabled these groups to better illustrate links between cultural and scientific knowledge in the group meaning map activity used in this research. This is worthy of further study in order to determine if explicit demonstrations and discussions could increase ability of students to make more links between knowledge domains.
Aikenhead and Jegede (1999) have referred to teachers as “travel agents - cultural brokers” whose role is to facilitate smooth border crossing by providing incentives to learn about science in the context of their everyday life. The Malawi school had the advantage of being a relatively new school. It had been operational for only two years at the time of the research, and it was a relatively small school with only one class in each year level. It is possible that the science teaching may not have been restricted by rigid curriculum guidelines and standards. A small student population (estimated 90 students) could have allowed more opportunities for meaningful relationships to develop between teachers and students.

The common ground (links in this study) draws upon an understanding of cultural knowledge and scientific knowledge as complementary, valid ways of knowing and understanding. All the student links (“food”, “animals”, “music” and ‘dancing”) represent areas in which scientific and cultural knowledge complement each other. A few studies have effectively used food and nutrition as common ground on which to draw on both scientific and cultural knowledge (Calabrese Barton & Tan, 2009; Tsurusaki, Calabrese Barton, Tan, Koch, & Contento, 2013). Similarly, the study of music and the use of street language in the science classroom have been found to resonate well with lower socio-economic urban youth who can be marginalized in the science classroom in a similar way as students from other cultures (Moje, et al., 2004; Tan & Calabrese Barton, 2010). The advantage of using music, food, dancing and clothing as common ground on which to connect cultural knowledge and scientific knowledge is that these are fundamental to all cultures; this is particularly pertinent in the context of the Australian multicultural classrooms. A science activity that asks students to explore science and food in their own culture could validate and legitimize other types of cultural knowledge as well as Aboriginal ways of knowing. Activities in the classroom that bring together cultural knowledge and scientific knowledge should go beyond surface level, tokenistic discussions and engage in critical discussions. Aikenhead and Ogawa’s revision of Stephen’s popular Venn diagram which characterizes the similarities and differences of traditional native knowledge and western science provides a platform on which teachers can begin discussions that weave threads through the themes of organizing principles, habits of mind, skills and procedure and knowledge (Aikenhead & Ogawa, 2007; Stephens, 2003).
2.6.4 Beyond facts and content knowledge

The highest number of group ideas fell in the theme *knowledge & understanding* which relates to factual information or concepts (*i.e.* “gravity”, “energy”, “forces” in scientific knowledge and “history”, “food” and “home” in cultural knowledge). Most links between the two domains of scientific and cultural knowledge occurred in this theme.

The lower number of group responses that fell in the theme *values, attitudes, beliefs & identity* unsurprisingly suggests a strong focus of teaching, at least in the science classroom, on content knowledge as opposed to the other strands of science. The nature of science is rarely taught in science classrooms at any level although it comprises important features of science such as its limitations, levels of uncertainty, biases and social aspects (Lederman, 2006; Ogawa, 1995). The 2012 Australian curriculum under the strand Science as Human Endeavour has a sub-strand on the Nature and Development of Science but teachers have often found it difficult to implement these conceptions in teaching practice (Lederman, 2006). Discussions and activities about the nature of science rather than content knowledge, particularly addressing science’s social aspects, limitations and biases, enable an open dialogue that can engage students in critical thinking and understanding of worldviews and cultural knowledge (Rosenberg, Hammer, & Phelan, 2006).

Results from the group meaning maps suggest that students perceive religion as a fundamental aspect of cultural knowledge. Research on multicultural education has often focused on science and culture and not much on religion. Religion as a belief system that shapes our worldviews is an implicit component of culture and worldview and thus has significant bearing in science education. Religion was also a concept that groups reported as connecting scientific and cultural knowledge. The interface between science and religion is often not discussed as this has the potential to raise controversial and divisive debates in science education, particularly in countries where fundamentalist religions have greater influence such as the USA (Baker, 2013). But as Cobern (1996) contends in his representation of worldview, for each individual the various components of worldview (religion, spirituality, gender, ethnicity and science) all interact dynamically. Yet some factors will have greater influence for any individual. For example including cultural perspectives and spiritual connections in science has led to positive outcomes for some indigenous students (H. Lee, et al., 2012; McKinley & Stewart, 2009). Taber, Billingsley, Riga, and Newdick’s (2011) UK study on students’
perceptions of the relationship between science and religion provides a useful guide on the importance of engaging students in meaningful discussion about their stances on science and religion. Taber et al (2011) found that secondary students’ (age 13-14) stances were often based on limited knowledge and that most students had hardly considered the connection between religion and science in any depth.

### 2.7 Conclusion

This study contributes to research on science and cultural knowledge by using a unique research methodology – group meaning maps – to reveal student perceptions of a common ground that merges the domains of science and cultural knowledge. Most student groups in this study were able to demonstrate that connections between scientific knowledge and cultural knowledge exist but most did so to a limited extent. It is unclear from our research whether these connections were taught in school, but these connections do provide a common ground, a third space or bridge for educators to discuss the relevance of science in a cultural context and vice versa. The Handbook for Culturally Responsive Science Curriculum provides myriad topics (e.g. medicinal and edible plants, use of local materials, navigation, tools and technology, shelter and survival) that can be used to integrate cultural knowledge and science (Stephens, 2003). However, classroom activities on the connections between different ways of knowing must go beyond token acts and allow students to reach a deeper level of understanding of the nature of science, worldview, religion and how those may relate to the values, attitudes, beliefs and identity of people from different cultures.

Based on our findings, we recommend that teaching practice include discussions of worldview and how it shapes different cultures and different interpretations of coming to know the world (H. Lee, et al., 2012). In addition to Aboriginal knowledge, teachers should encourage student awareness of contributions to modern knowledge from different cultures. We make that recommendation with awareness of the difficult tasks faced by modern science teachers who teach in an environment following decades of attempted reforms of science school curriculum (Davis, 2003; Fensham, 2008; Stocklmayer, et al., 2010). However, teachers have an important role to play in bridging divides between different ways of knowing, acting as cultural brokers and travel agents, teaching science in a context that encourages students to incorporate it in their worldviews such as appeared to have happened in the Malawian school in this study.
Teachers need to acknowledge the cultural diversity in their classrooms and be aware that Aboriginal students and students from other cultures are not a homogenous group. Their students, including Aboriginal students, come from various backgrounds and have had different modern influences on their worldview. By acknowledging classroom diversity, equitable access and academic achievement can be more readily realised for all students. Multicultural science education for Aboriginal students and students from other cultures can lead to the development of positive cultural identities and improvements in participation in science (Cobern & Loving, 2004). For non-Indigenous students an awareness of other cultures’ contributions to science improves knowledge and promotes attitudes that will enable students to engage in meaningful positive interactions with people from diverse cultures (Hodson, 2003; Ladson-Billings, 1995).
Preface

In Chapter 2, we examined how Australian and Malawian students understand the terms scientific knowledge and cultural knowledge and the relationships between the two conceptions. In the next chapter, we shift our focus from examining understanding to exploring Australian students’ beliefs about representations of scientific knowledge and cultural knowledge within the context of informal science education. Results from the Malawian school were excluded from this part of the study because recurring themes were found in the Australian cohorts that tell a coherent story about youth beliefs. Our findings describe youth beliefs about scientific and cultural knowledge and the role of narratives of objects in enriching understanding of culture and communities.
3 Objects as stimuli for exploring youths’ beliefs about cultural and scientific knowledge

3.1 Abstract

An object-based activity – science and culture story box – was designed, developed and used to explore young people’s beliefs about cultural knowledge and scientific knowledge. In informal education spaces (e.g. museums and science centres), culture is often presented via representations of easily observable features of ethnicity such as music or dress. The development and application of knowledge in culturally diverse communities can be difficult to visualise and is rarely presented. Instead western science often dominates as the authoritative, valid, systematic and useful way of thinking. The intersection of science and culture, although challenging, can create a platform for meaningful dialogue and valuing of a variety of cultures. Using an informal science education lens, this research investigates young people’s beliefs about different knowledge systems. Six cohorts of Western Australian young people (age 12-16; \( n = 171 \)) participated in the study. The activity involved assigning 17 photographs of objects and or processes (e.g. medicine, lightning, etc) onto a Venn diagram of scientific knowledge, cultural knowledge or both. Photographs were taken of the resulting Venn diagrams showing association of items with knowledge domain. This was quantified to show the number of times an item was associated with scientific knowledge, cultural knowledge or both. Group discussions were audio recorded and transcribed. Thematic analysis of discussions and items to knowledge domain associations revealed intriguing themes and perspectives. Young people associated technology with electronic devices and scientific knowledge and not cultural knowledge. Young people conceived culture as old and basic and science as new and progressive. There were also impressions expressed that cultures do not ‘do’ science and that skin colour determines culture. No clear or consistent conception emerged of Australian culture. These young people’s perspectives are discussed within the context of meaningful intercultural understanding in multicultural societies.

Keywords: objects, story box activity, scientific knowledge, cultural knowledge, intercultural understanding, informal education, museums
3.2 Introduction

By integrating frameworks from museum studies, cultural anthropology and informal education; we construct an argument for using science and technology as a launch pad for inspiring intercultural understanding amongst young people. In this study we used photographic representations of objects, processes and events to illuminate the research question – How do young people conceptualize scientific and cultural knowledge? This research contributes to a critical understanding of the identification of biases and beliefs that constrain meaningful cultural discourse. We begin by describing the multicultural context of Australia. This is followed by the recognition of the role of informal spaces such as museums in promoting multicultural understanding. We then use this to argue for informal spaces portraying the connection between science and culture. This is made difficult by the contentious academic debate on the definition of culture. We consider that if there is no scholarly consensus on the definition of culture, then young people may have biased conceptions of science and culture. These arguments provided impetus for the development of the science and culture story box activity to further explore young people’s beliefs about scientific and cultural knowledge and the connections between the two domains.

3.3 Multiculturalism in Australia

Australian society is culturally diverse: one in four of Australia’s 22 million people was born overseas, more than 260 different languages are spoken and over 270 ancestries are recognised (Department of Immigration and Citizenship, 2011). By definition, a multicultural society is composed of many different cultures; however this does not necessarily mean that within these societies different ethnic groups interact with each other in a mutually respectful and informed manner (Ozturgut, 2011). Shortcomings of multiculturalism occur when multiculturalism does not combat social inequality but instead promotes notions of participation of “cultural others” that is limited to essentialist and decorative activities such as song, dance, music, food and leisure (Ozturgut, 2011). Intercultural understanding, on the other hand, is the ability to critically reflect on the value of one’s own and other cultures, language and beliefs and in doing so, be able to respectfully participate and engage with people in a variety of contexts (de Leo, 2010). The benefits of diversity and improving young people’s intercultural capabilities include intellectual growth, improved academic skills and enhanced cultural engagement (Gurin, Dey, Hurtado, & Gurin, 2002).
Intercultural understanding permeates all facets of society, however making cultural connections is less common in science than in other endeavours such as the arts. There are a number of benefits and limitations to using science as a lens to motivate intercultural understanding. To begin with, science is generally recognised in society as useful and important. Additionally the increased calls for developing young people as global citizens and the movement towards globalization of science education (DeBoer, 2011) and incorporation of indigenous perspectives in the Australian national science curriculum (Austin & Hickey, 2011) mirrors the ideals of intercultural understanding. Therefore science does provide a suitable frame in which to engender the principles of intercultural understanding. Science’s dominance and assumed authority, applicability, value and use, as the pursuit of knowledge, provides an opportunity for young people to learn about ways of thinking and knowledge production within different communities. Furthermore by understanding how knowledge about the natural world is developed and used in culturally different societies, commonalties can be found and shared, supporting intercultural understanding and learning in other areas such as religion, history, or politics. Exploring conceptions of culture underpins a critical reflection by young people on the value of their own and other cultures.

### 3.4 Representations of science and culture in informal spaces

Museums as institutions that house and display culture have an important and prestigious role in educating the public (Conn, 2006). Their purpose is to collect, document and conserve time, place, environment and people. Public historian Steve Conn writes “museums still speak to most people with voices of authority and legitimacy. Trading on that legitimacy to make us all more literate scientific citizens might well be the greatest function science museums could serve” (Conn, 2006, p. 507).

Museums display objects and artefacts. Objects are chosen for display for a number of reasons: they may represent a significant scientific finding, an important historical artefact or be a representation of an interesting or important place, group or time. Objects are displayed to encourage visitors to consider different perspectives or to evoke reactions like wonder, realization, personal connection or puzzlement. It is commonplace for exhibitions to be developed using the tacit knowledge of curators and
design teams (Laherto, 2013). Curators identify objects and then work backwards to connect them to an overarching area of disciplinary knowledge for an exhibition (Knutson, 2011). In the past has this lead to indiscriminate presentations of indigenous objects which anthropologist Julie Cruikshank (1995) in her ethnographic work with Native American communities criticized as fixed, ahistorical, apathetic representations which lacked subjectivity, and ignored political and social histories, environmental and economical challenges in which knowledge is produced. A 1982 exhibition ‘Science in India’ at London’s Science Museum gave rise to much debate and controversy on how to represent Indian science and technology (Sen, 2012). The British curators wanted to represent poverty and appropriate technology through a bullock cart whilst the Indian organizers wanted to showcase progress through a display of their satellite program. This disagreement echoed debates in which Indians said international exhibits were misrepresenting India through displays of tokenistic material culture.

To address these tokenistic representations, the concept of museums as contact zones was developed in the 1990s to shift the dominance of museum staff as authoritative experts to museums as spaces inclusive of and giving voice to indigenous communities (Clifford, 1997; Pratt, 1991). An example of museums as contact zones is Srinivasan and colleagues’ work with the Zuni, a Mexican tribe (Srinivasan, Becvar, Boast, & Enote, 2010). They compared descriptions of museum objects in Cambridge University’s Museum of Anthropology and Archaeology catalogue and descriptions given by Zuni from whom the objects originate. They found the catalogue descriptions were divorced from meaningful representation, meta-data written for the purpose of “object as specimen” rather than “object as embedded…acting within a larger, dynamic cultural, and discursive system” (Srinivasan et al. 2010, 35). Objects should be considered carriers of knowledge that have emerged from a local context (Trofanenko, 2006). Objects and their curatorial labels should function as powerful vehicles for sharing knowledge and multiple perspectives, especially if they are presented in light of their relevance to their community of origin (Srinivasan, et al., 2010). However not all museums have taken on the contact zone advancement. Some museums are still being criticized for essentialising indigenous identities mainly as art (Trofanenko, 2006) whilst science museums are only beginning to embrace juxtaposing indigenous perspectives alongside western science.
A report by the Institute of Museum and Library Services (IMLS) and Learning Science in Informal Environments: People, Places, and Pursuits (LSIE) found limited studies on the impact of artefacts on promoting cultural connections, encouraging understanding of local and global issues and supporting a sense of identity (Semmel, 2010). An internet search on Centre for Advancement of Informal Science Education (CAISE), Association of Science and Technology Centres (ASTC), European Network of Science Centres and Museums (ECSITE) and Asia Pacific Network of Science and Technology Centres (ASPAC) websites did not reveal any exhibits whose goal was making connections between scientific and cultural knowledge or promoting intercultural understanding of their connections. This search (albeit not exhaustive) indicates that exhibits that combine science and culture are not commonplace.

Imiloa Astronomy Centre in Hawaii is one of the most comprehensively developed science centres that juxtaposes indigenous knowledge with western scientific knowledge. The Museum of Science and Technology in Islam in Saudia Arabia and their popular touring Sultans of Science exhibit presents Muslim scholars’ scientific and technological breakthroughs that contributed to modern science. The Gravity Discovery Centre north of Perth, Western Australia (which was the venue for some of the research reported in this thesis) has a Cosmology Gallery in which different cultural understandings of the creation of the universe are depicted in artistic representations. However what remains, despite some of these advances in scientific and cultural representations, is finding a strategy in which multiple ways of knowing objects from various stakeholders can be displayed and interrogated by visitors. Appropriate cultural representations and their connection to science is further hampered by an elusive definition of culture.

### 3.5 Definitions of culture

There is passionate debate on the definitions of culture in psychology, anthropology, education and museum studies (Baldwin, Faulkner, & Hecht, 2006). In psychology, a common conceptualization of culture is a system of beliefs, values and norms that influence behaviour (Shweder, 1990). In cultural psychology, culture is understood as a set of practices that are enacted through participants’ engagement with their local community (Shweder, 1990). The classic anthropology perspective of culture - similar to the cultural psychology definition - views culture as characteristic practices or ways
of life within a social group which are passed down from one generation to the next (Eisenhart, 2001). In these commonly accepted definitions, there are multiple cultures stemming from different societal groups with no overlap between cultures. Each culture is distinct; for example Muslim culture is different from Aboriginal culture. This perception is reflected in cataloguing and categorizing of cultural artefacts in museums according to geographic origin, for example Western African artefacts or Native American artefacts (Srinivasan, et al., 2010).

Science educator Gale Seiler (2013) highlights two limitations of the popular classic definition of culture. Firstly, the pluralizable discontinuous view of culture creates an expectation of difference between cultures and secondly it posits homogeneity within each culture. This promotes stereotypical fixed views. Understanding culture in this way leads to token strategies that essentialise cultures based on characteristics such as skin colour and language (Gutierrez & Rogoff, 2003). Furthermore, a pluralizable view of cultures conceals any overlap between cultural worlds. It sets cultures apart, further suggesting that resources cannot be transferred or shared between cultural groups (Seiler, 2013). Seiler adds that this pluralizable conceptualization of culture fixes cultures, in that no matter what is in informal and formal education spaces, cultures will remain fixed and distinct. This is further reiterated by cultural education scholars Gonzalez, Moll and Amanti (2013) who put forward funds of knowledge as historically accumulated skills, ideas, practices within communities, refraining from using the term culture “because the term culture is loaded with expectations of group norms and often-static ideas of how people view the world and behave in it” (p. 10).

Seiler (2013) advances culture as a metaphorical construct. She draws on two perspectives: from Sewell (1999) whose view is of culture as more permeable, loosely bounded, and variable, and from Eisenhart (2001) whose standpoint is culture as locally produced, complex and constantly contested, where young people enact culture through merging different meanings, discourses and materials. The shift in this new conceptualization as presented by Seiler is from culture as an entity to culture as production where people acquire and use cultural resources. Culture as a metaphorical construct provides a useful approach in which to foster intercultural science understanding. Understanding how young people construct their definition of culture, their biases and assumptions is an important step in redefining culture and linking it to
science. The objective of this research was to explore young people’s beliefs about scientific and cultural knowledge.

3.6 Theoretical framework for the story box activity

In the context of multicultural Australia, we argue for using science and technology to inculcate intercultural understanding and propose a role for object representations in informal spaces in promoting this agenda. However we suggest that in order to encourage intercultural science amongst young people, we should begin by exploring young people’s beliefs about scientific and cultural knowledge. Our theoretical framework draws on approaches from informal education, museum studies and cultural anthropology.

It is challenging to assess learning in informal environments especially if examining socio-cultural perspectives of non-Western cultures (Kisiel & Anderson, 2010). Fienberg and Leinhardt (2012) provide some insight in their study, which is one of several studies through the Museum Learning Collaborative that looks at how learning occurs in a museum. The Museum Learning Collaborative takes a sociocultural perspective on learning. They consider that conversations allow group members to share and build on each other’s knowledge and understanding. They consider that three elements interact during conversation: visitor’s identity, the structure of the learning environment and the extent of explanatory engagement. Conversations reflect visitors’ identity and mediate understanding. Visitors seek to make meaning not only around the content or object that is provided but also based on their membership in a particular group and what they value. The Museum and Learning Collaborative considers conversational elaboration an outcome of learning in museums. They describe four levels of engagement – 1) listing: simple identification through phase or features of an object without any expansion; 2) analysis: interpretation of features of the object; 3) synthesis: integration of multiple ideas from various sources of information e.g. from home, school etc in order to validate an idea; 4) explanation: combines analysis and synthesis to help another group member understand the what, the why or how of a particular object.

Our study, similar to those of the Museums Learning Collaborative, was premised on social constructivism, a theoretical framework which posits that groups construct knowledge through social processes similar to Vygotsky’s social constructivism.
(Vygotsky, 1978). We focused on conversations as important drivers of learning in museums because conversations demonstrate the ways in which we have been socialised. Conversations can reveal cultural mediation, the ways in which culture influences how people construct the world (Teo, 2013). Cultural mediation refers to human beings as social agents that participate in sociocultural collaborative practices that are built on and related to past generations, families, peers, and the environment (Stetsenko & Vianna, 2011). When young people interact with others through conversation, they express their points of view, counter or accept their peers’ points of view (Teo 2013). Conversations can be examined to assess group norms, values, and differences in opinions (Teo 2013).

In addition to social constructivism and cultural mediation practice theory reinforced our theoretical framework. Practice Theory focuses on the idea that people are not only influenced by their social structure, but influence their social structure as well (Eisenhart, 2001). It analyses the dynamic relationship between established structures of culture and people (with diverse intentions, motivations and identities). Practice theory considers micro- (personal) and macro- (group) factors of behaviour. It combines ideologies from cultural production, situated learning and networks of power (Eisenhart, 2001). A unified theory of practice does not exist but practice theory is still a useful theoretical frame to analyse how certain subject positions are either esteemed or sidelined in a particular setting and the conditions which create such standpoints (Holland, Lachicotte Jr, Skinner, & Cain, 2001). Through practice theory, researchers can connect local standpoints to larger sociohistorical cultural meanings. Larger societal structures establish cultural norms that constrain individuality and persons conform to societal ideals (Eisenhart, 2001). Individual actions reveal something about societal norms and shared meanings. Most individuals will behave in ways that align with shared cultural meanings. They can ‘be identified, not by individual statements of belief, but by patterns in the ways participants act in classrooms, label their own efforts, and describe themselves to others’ (Eisenhart, 2001, p. 217). Practice theory provides a research lens in which power relations can be studied so that dominant systems can be challenged and dismantled. In Carlone and Johnson’s (2012) longitudinal study of Latino children, the researchers use practice theory to unpack “ways local practices produce group-level meanings of ‘science’ and ‘science person’ that align with and/or contest larger socio-historical meanings” (p. 165).
Practice theory and social constructivism guided and informed the manner in which the research in this chapter was theorized, conducted and interpreted. Activities that are based on social constructivism create opportunities to observe how meanings are developed and assigned. Collaborative social learning interactions provide young people with an opportunity to self reflect and engage in a space in which they can co-construct meaning and understanding (Knutson, 2011) and so influence a shared social understanding.

3.6.1 Design considerations

The use of objects to stimulate conversations that explore young people’s beliefs about scientific and cultural knowledge in an informal settings were premised on our theoretical framework, and a number of design considerations for the story box activity.

There was the potential for young peoples’ discussions to be controversial; therefore the environment needed to be safe, inclusive and supportive. This was considered challenging as the young people were meeting the facilitator for the first time in unfamiliar settings. A fun and familiar example activity, a group meaning map on Books and Movies was conducted at the start of the activity as an icebreaker to encourage the participants to call out without having to raise their hands. Asking participants to call out their responses created an environment that was different to the normal classroom where students have to raise their hand and the teacher as the authority figure chooses who answers. The teachers that were present during the activity were assigned seats at the back of the room and were asked not to participate in the activity to avoid biasing participant responses.

Other intentional actions to reduce power distance between the facilitator and the young people included: stating repeatedly that there were no right or wrong answers; the facilitator (author) dressing in t-shirt and jeans and establishing a rapport with a students by asking them to call her by her first name and sharing personal details (e.g. about where she came from). The room was set up to encourage group discussion; tables and chairs were arranged so that participants in their small groups were facing each other. With group discussions, there is always the potential for a group member to dominate. The introduction of “red cards” for any disputes was considered but whether the less dominant members would use the cards was uncertain. It was decided that the red cards added an additional layer of complexity and were abandoned.
The activity incorporated facilities at the Gravity Discovery Centre, one of the project partners on this Science Education Enrichment Project. The Gravity Discovery Centre is a science centre located 90 km north of Perth, Western Australia’s capital. The foci at the Gravity Discovery Centre are gravity and cosmology. Facilities at the centre include the Cosmology gallery with a timeline of the scientific creation of the universe, an art exhibition which depicts cultural understandings of the creation of the universe, a hall with interactive exhibits on physics, gravity and space, and the Leaning Tower of Gingin which is based on the Leaning Tower of Pisa.

Initially the idea of the story box activity was to use actual physical objects in a box with young people sharing stories about items they perceived at the scientific knowledge and cultural knowledge interface – hence the name science and culture story box. However due to logistical, financial and time constraints, the use of the physical objects and a box was abandoned and photographs were used instead. One advantage of using images instead of physical objects was images allowed for a variety of items to be used that would have been difficult to source or represent (e.g. an Aztec calendar and images depicting lightning). It also allows the opportunity for replication of this research in other venues.

Western Australia is a multicultural society. Representations could not depict objects or events from all ancestries in the different groups but needed to represent many cultures. However, the need to ensure access for a multicultural population had to be balanced with localized examples. Previous research has found that young people fail to recognise that cultures adapt and that indigenous cultures are dynamic (Cruikshank, 1995). A representation was sought that could potentially stimulate discussions on how non-western cultures are dynamic and adaptive. At the same time, the activity had to provoke meaningful discussions and provide rich data. The use of interesting representations could address this dilemma to a certain extent.

Other issues that we were cautious of were: the facilitator (author) imposing her value and belief system on the participants during discussions as well as being aware that her cultural background – female Malawian (African) – could influence the students’ responses, for example in not providing contentious answers related to African cultures.
The time allocated for this activity during school excursions was 30 minutes. Snapshot activities sometimes do not yield good results or rich data if rapport has not been established with the research participants, especially when discussing potentially controversial issues. An attempt was made to overcome this by allowing young people to work in groups with their peers. The discussions needed to go beyond surface-level discussions and elicit meaningful constructive dialogue. This was attended to by the facilitator sitting in on few small group discussions and asking probing questions like: “Why would you say that?” “Does everyone agree?” “Who has another point of view?” and also asking similar probing questions during the whole classroom discussion. The final selection of images was based on a number of criteria: interestingness (e.g. running shoes), familiarity (e.g. iPhone) as well as the unfamiliar (e.g. retina of zebrafish), different cultural contexts (e.g. winnowing basket from Malawi), ease of association (e.g. lab beaker). Images were chosen so that some would almost guarantee only scientific knowledge association like the lab beaker and others could solicit mixed responses like the guitar, soccer ball and medicine.

3.7 Methods

3.7.1 Participants
Six cohorts (171 young people) participated in this study (Table 3.2). The cohorts were selected based on purposive sampling of schools in Western Australia.

3.7.2 Data collection
The science and culture story box activity was designed to study young people’s beliefs about scientific knowledge and cultural knowledge through the photographic representation of objects, events and processes. The activity was conducted at an informal science centre, the Gravity Discovery Centre, or during a group excursion to the University of Western Australia. The science and culture story box activity involved participants working in small groups of three to four and placing photographs that represented objects, processes or events within a two set Venn Diagram. The sets were scientific knowledge or cultural knowledge and the intersection implied both. Participants were provided with an envelope containing 17 images depicting events or objects (see Table 3.1 and Appendix 1). All groups were provided an identical set of images. Participants were asked specifically to “look at the image and reach a group consensus on whether what was depicted in the image represented something they associate with scientific knowledge or cultural knowledge or both”.

69
Table 3-1

*Items used in the science and culture story box. (Appendix 1 provides the images used. Appendix 2 describes science and culture story box lesson plan).*

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>“When the humming bird comes, it is time for the seed to be planted. The humming bird never lies.”</td>
<td>Proverb from Zuni, a Mexican tribe.</td>
</tr>
<tr>
<td>Aztec calendar</td>
<td>The Aztecs used two different calendars, one measured time, while the other was used to fix religious festivals. The time-measuring calendar was used to fix the best time for planting crops, while the religious calendar told when to consult the gods.</td>
</tr>
<tr>
<td>beaker</td>
<td>Container for stirring, mixing and heating liquids commonly used in many laboratories.</td>
</tr>
<tr>
<td>Coartem</td>
<td>Antimalarial drug developed from the artemether/lumefantrine. Arthemether is isolated from the Chinese antimalarial plant, Artemisia annua, Chinese sweet wormwood.</td>
</tr>
<tr>
<td>Global Positioning System (GPS) (Tomtom)</td>
<td>Space-based satellite navigation system that provides location and time information.</td>
</tr>
<tr>
<td>guitar</td>
<td>Guitars feature prominently in music of a number of cultural groups. The science of sound is also well studied.</td>
</tr>
<tr>
<td>lightning</td>
<td>There are many cultural interpretations and a scientific explanation of lightning.</td>
</tr>
<tr>
<td>mobile phone (iPhone)</td>
<td>Form of communication.</td>
</tr>
<tr>
<td>running shoes (Nikes)</td>
<td>Popularly worn sports footwear.</td>
</tr>
<tr>
<td>Shaman treating a patient with smoke</td>
<td>Indigenous approaches to healing.</td>
</tr>
<tr>
<td>soccer ball</td>
<td>Soccer is a sport in a number of cultural groups. There are several scientific connections through sports science.</td>
</tr>
<tr>
<td>The Dreaming</td>
<td>The Dreaming for Aboriginal people (sometimes referred to as the Dreamtime or Dreamtimes) is when the Ancestral Beings moved across the land and created life and significant geographic features. This painting tells a Creation story and has a number of star constellations.</td>
</tr>
<tr>
<td>Tupac Shakur</td>
<td>Famous American hiphop artist who died in a drive-by shooting.</td>
</tr>
<tr>
<td>wedding dress</td>
<td>Represents marriage but also requires understanding of fashion design, materials and textiles.</td>
</tr>
<tr>
<td>winnowing basket</td>
<td>Basket used to separate rice grains from the husk by throwing at a height. Hand woven reed baskets also been studied for their fractals - repeating patterns.</td>
</tr>
<tr>
<td>zamia (jeeriji)</td>
<td>Europeans who first came to Australia ate the nuts. They are poisonous when raw. Aboriginal (Noongar) people have the knowledge on how to prepare the nuts to remove the toxins.</td>
</tr>
<tr>
<td>zebrafish retina</td>
<td>This image won a Wellcome Image award in its depiction of science and art. This image was created using a staining technique that identifies gene products.</td>
</tr>
</tbody>
</table>
Table 3-2

*Description of cohorts.*

<table>
<thead>
<tr>
<th>Cohort (code)</th>
<th>Site (of cohorts)</th>
<th>Number of participants</th>
<th>Year level</th>
<th>Ancestries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quandong (Y)</td>
<td>GPFF regional</td>
<td>18</td>
<td>Yr 7-9</td>
<td>Aboriginal, Australian, Irish, German, New Zealander</td>
</tr>
<tr>
<td>Rainbow (G)</td>
<td>Metropolitan</td>
<td>30</td>
<td>Yr 7</td>
<td>Aboriginal, Australian, English, Ethiopian, Japanese, Kenyan, Libyan, Malaysian, New Zealander, Romanian, Serbian, South African, Thai, Ukrainian</td>
</tr>
<tr>
<td>Brown (B)</td>
<td>Metropolitan</td>
<td>38</td>
<td>Yr 7</td>
<td>Aboriginal, Australian, Chinese, Dutch, Greek, Indian</td>
</tr>
<tr>
<td>Cyan (C)</td>
<td>Metropolitan</td>
<td>25</td>
<td>Yr 7</td>
<td>Aboriginal, Australian, American, Chinese, Dutch, Eastern Block, Italian, Irish, Jewish, Singaporean</td>
</tr>
<tr>
<td>Magenta 1 (Mgi)</td>
<td>Metropolitan</td>
<td>28</td>
<td>Yr 9</td>
<td>Australian, Burmese (Myanmar), Chinese, Hong Konger, Indian, Korean Republic, Malaysian, Mauritian, Mexican, Nepalese, Pilipino, Singaporean, Serbian, Taiwanese</td>
</tr>
<tr>
<td>Magenta 2 (Mgii)</td>
<td>Metropolitan</td>
<td>24</td>
<td>Yr 9</td>
<td>Australian, Chinese, Ethiopian, Ghanaian, Singaporean, Malaysian</td>
</tr>
<tr>
<td>Maroon (Mr)</td>
<td>GPFF metropolitan</td>
<td>8</td>
<td>Yr 8-12</td>
<td>Aboriginal, Australian, English, Irish, New Zealander</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>171</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

GPFF = Graham Polly Farmer Foundation

This terminology was used in all instances so that participants could loosely interpret “associate” and come to different meanings and understanding of the events and objects represented in the images.

Two randomly selected groups in each cohort had their group discussion audio recorded. When participants had completed the group task, pictures were taken of each cohort’s completed set allocation for data analysis. Following this, the facilitator (first author) initiated a discussion with the entire cohort which was audio recorded. For each image, the facilitator probed by asking questions such as: “Why do you say that”, “Do you agree?”, “Are there any other ways to look at this?”
There was potential for socially desirable response bias and race of interviewer effects on participant responses. However, being a cultural other (black African) was advantageous in that the facilitator could probe for detailed responses that someone from the same cultural group would not have been able to. For example when probing about Australian culture, naïve questions could be asked and participants could respond with less fear of being judged (Tinker & Armstrong, 2008).

3.7.3 Data analysis

Three sources of data were utilized to assess young people’s beliefs about scientific and cultural knowledge: photographs of Venn diagrams showing placements of items into cultural, scientific knowledge or both (n = 44), audio recordings of two group discussions per cohort relating to decisions about those placements (n = 12) and the entire cohort discussion at the end of the activity (n = 6). The photographs of Venn diagrams were used to count how many groups placed which item in which set. A chi-square test of association was performed to test whether there was a relationship between the photographic representation and domain (scientific knowledge, cultural knowledge or both) the object was assigned to; for example was there an association between wedding dress and cultural knowledge? One limitation to the analysis was that data were only collected for the ancestral composition of the entire cohort and not for the small groups. This precludes comparisons and exploration of patterns between the ancestral composition and group discussion.

All audio recordings of group and entire cohort discussions were transcribed and analysed. This research used natural talk and an attempt was made not to pose leading questions which would affect reliability (Kvale & Brinkmann, 2008, p. 245). Thematic analysis is suited for this study as it focuses on understanding how meaning is created in conversation (Kvale & Brinkmann, 2008). Thematic analysis was used instead of content analysis because it is more sensitive to meaning, sorting and linking whereas content analysis aims more at quantification of specific terms (Braun & Clarke, 2006). Discourse analysis (Creswell, 2008) was not employed because it goes beyond investigating meaning making to looking linguistically at how words and phrases are linked during discourse and how the implied meanings changes in comparison to other similar phrases or words. This level of detail was beyond the scope of the research question which examined young people’s conceptualizations of scientific and cultural
knowledge. Using social constructivist and practice theory analytic approaches, themes emerged from the data that related to the research question (Yin, 2003).

Thematic analysis began with a thorough reading of the transcripts of all twelve groups. Thematic analysis was undertaken at a latent level to interrogate underlying assumptions and conceptualizations. A detailed reading of transcripts revealed that most groups at the start of the activity discussed a system of organizing the representations, followed by categorising the representations. Discussions about each representation were then analysed together; for example all groups’ discussions related to the basket were combined. A further assessment was done on the combined discussion of each representation to investigate whether the group assigned the representation to scientific knowledge, cultural knowledge or both and what rationale they used in their assignment. Coding labels such as progressive, technology, historic, electronics, were put forward, applied, tested, reviewed and revised.

Comparisons were then made across the different representations and different rationale for assigning the representation to scientific knowledge, cultural knowledge or both. i.e were there any similarities or differences in the way different groups assigned basket to scientific knowledge, cultural knowledge or both. Patterns were discovered across the groups and representations for example if a representation was electrical it was considered scientific knowledge or how representation looked determined if it was cultural. Transcript data were analysed for similarities, differences and patterns until data saturation was reached with no new themes emerging.

The next stage involved looking at themes and refining them to capture the essence of the story they were telling about the data (Braun & Clarke, 2006). Themes either found relationships amongst groups or were rare but interesting insights that were then analysed in the context of our theoretical framework. This involved combining a number of themes for example the themes science makes things better and culture is basic old knowledge were combined to “culture is old – science is new and progressive”.

Validity was embedded through reflexive practice, continually checking, critically questioning and using theoretical frameworks to interpret findings. A lack of shared culture between researcher and participant can hinder analysis, however, in our research
we believe the researcher’s limited familiarity with the experiences of respondents allowed more critical analysis of respondent assumptions (Tinker & Armstrong, 2008) for example on participants’ underlying meanings of technology.

### 3.8 Findings

Knowledge representations as determined by placement of photographs on the Venn diagrams and discussions of the cohorts of young people revealed five key themes:

- Technology is electronics and is only scientific, not cultural;
- Culture is old – science is new and progressive;
- Cultures do not do science;
- Black people are cultural and Australia is mixed; and
- Diverse factors can be used to categorize images.

These themes are illustrated in the following sections with verbatim quotes that represent the voices of the participants.

#### 3.8.1 Knowledge representations

There were differences in classification of the different representations with images like beaker being placed entirely in the science domain and The Dreaming painting being placed most often in the cultural domain (Figures 3.1 and 3.2). An association between image and domain knowledge was found, $\chi^2 (32, N = 748) = 510, p < 0.001$. Assuming an expected frequency based on the independence of variables (i.e. no association with image and domain), significant associations were found for the beaker ($p < 0.001$), GPS ($p < 0.001$), Tupac ($p < 0.001$), basket ($p < 0.001$), iPhone, ($p < 0.001$), Dreaming painting ($p < 0.001$), Coartem ($p < 0.001$), Jeeriji ($p < 0.001$), Lightning ($p < 0.001$), Aztec calendar ($p < 0.001$), guitar ($p < 0.001$) and hummingbird ($p < 0.001$). No significant associations were found for wedding dress ($p = 0.008$), running shoes ($p = 0.002$), haman ($p = 0.002$), soccerball ($p = 0.005$) or zebrafish ($p = .426$).

The beaker was the only image that was classified by all groups as being associated only with scientific knowledge (100%, $n = 44$). Images classified predominantly (above 70%) as associated with scientific knowledge were GPS (86%, $n = 38$), iPhone (84%, $n = 37$) and Coartem (82%, $n = 36$). No image had all student groups classifying it solely as cultural knowledge but a few images predominantly (above 70%)
classified as cultural knowledge were The Dreaming painting (82%, $n = 36$), basket (77%, $n = 34$), Tupac (73%, $n = 32$) and the Aztec calendar (73%, $n = 32$). The images that had variable responses across all knowledge domains were jeeriji, guitar, soccer ball and running shoes (Figure 3.1).

In most instances, if an image was placed by a majority of groups in the scientific knowledge domain then the remaining group placements were in the “both” intersection for example GPS was 86% scientific knowledge and 14% both. Similarly with an image that was placed predominantly in the cultural knowledge domain, the remaining responses were mainly placed in the ‘both’ intersection; for example The Dreaming painting was 82% cultural knowledge and 18% both. However a few images did not fit this trend. Although the wedding dress was predominantly seen as fitting in cultural knowledge (64%), it had responses in ‘both’ (20%) and scientific knowledge (16%). Likewise running shoes, the shaman, soccer ball and the zebrafish had responses spread across the knowledge domains (Figure 3.1).
3.8.2 Group and cohort discussions

Cohorts had consistent conceptualisations which they associated with the different representations of scientific and cultural knowledge. Participants engaged in varying levels of conversational elaboration although the most common was the basic levels of listing and analysing features (Fienberg & Leinhardt, 2012).

Technology is electronics and is only scientific not cultural

Images that groups perceived as technology were mostly placed in the scientific knowledge domain. A participant from Magenta cohort (Mgii) explicitly stated “Oi. Put all the technology in scientific.” A Brown group member began their placement by using electronics as a category. “First join all the electronics together.” Technology was described as items that are electronic or require charging. An Aboriginal participant from the Maroon cohort argued how a winnowing basket and a GPS are both technology and that making a basket requires scientific knowledge:

Mr1: Well not like GPS type knowledge technology but it is still technology cause it has the ability to separate rice if that makes sense. And it kind of started off as technology. It developed in someone’s brain.

Mr2: Doesn’t it have to have electronics?

MG¹: What is technology? Explain that to me. What do you understand by that?
Mr3: Anything that can work.

Mr2: Something that has the ability to do something else. If that makes sense.

Mr3: Something that you charge.

MG: So can we put technology into both scientific and cultural knowledge?

Participants: Yes.

MG: You put the GPS in scientific knowledge and the basket in cultural knowledge but they are both technology, why?

Mr1: You can put them both in the both part. Cause the GPS is like the Nikes that everyone uses them everyday but yet they are scientific. But they’re still being developed. In the next couple of years we are going to have a better GPS, better sneakers, better rice differentiation what ever it is called. Everything is just going to keep on developing and different cultures are going to make them and going to make them better.

MG: So if this was electric in some way would you then put this in scientific knowledge?

Participants: Yes.

Mr1: I would put that in scientific knowledge anyway.

MG: You would… Why?

Mr1: Because … scientific knowledge does not have to be like technology as in GPS technology; it still can be used as in like that.

Mr4: As in an early invention.

Mr1: It still is going to separate the water from the rice which is still science so it’s both; it’s cultural and science.

1MG is first author

These views were relatively unique amongst participants and Mr1 struggled to articulate to the rest of cohort why a winnowing basket and tools made by indigenous communities could be considered scientific knowledge. He attempted to explain that tools developed by scientists and other cultures can be further developed and improved upon. This participant used the fourth level of engagement – explanation; he attempted to combine different interpretations whilst the rest of group simply listed and identified features without elaborating. Two participants provided an appropriate definition of technology yet did not conceptualize technology as a non western-scientific endeavour. This may suggest that participants perceived technology in the scientific sense as being electronic but technology in the cultural sense was more primitive and outdated as
suggested by the phrase “early invention”. Participants in another cohort conceptualized man-made things e.g. mobile phone and shoes as science because “they are created” but nature such as plants as cultural because “they are not man-made”.

**Culture is old – science is new and progressive**

A recurring theme expressed by participants was that cultural knowledge is old and outdated while science is new, modern and making things better. At the end of the activity, a participant from Brown cohort was asked to summarize their impression of the cohort’s agreement and discussion.

B1: It’s pretty much that fully cultural things are things that are way back or come from way back and the scientific things are things that come from now-ish but the ‘both’ [middle domain] is pretty much things we found in the past and we brought forward and maybe made it futuristic and improved it somehow.

The concluding statement above was provided by a white male Australian participant. In this context it is unclear what the pronoun “we” may refer to; it could be “people today” (in general) or “scientists” or “Australians”. Using “we” suggests that he belongs to that group so it could be implied that it is “people of today” but this is confounded by the observation that he uses it in connection to improving things, suggesting that he may be using it in the context of “scientist” and possibly considering himself as a scientist. The theme of science improving on cultural knowledge was also highlighted in discussions with Aboriginal participants from Maroon cohort. When agreeing with science improving on cultural knowledge, one Aboriginal participant also suggested that science had “stolen” from cultural knowledge.

Mr1: History. It’s kind of like how different cultures have been around for certain amount of times, when scientists have come along they have just leached off the cultures and developed all this really cool stuff that takes multiple people’s brains.

The distinction between science as new and culture as old also extended to labelling of the items that were represented. A Magenta participant made a distinction during discussions on running shoes (Nikes) between shoes and sandals; sandals were cultural knowledge - primitive and basic - running shoes (Nikes) were footwear science.
A common theme that coincided with science as new and modern and culture as old and outdated, was the progress of science. Terms like “futuristic”, “improving”, “making things better” were often associated with science whilst “way back”, “ages ago”, “back before”, “history” and “in the past” were used with culture.

**Cultures do not do science**

There were objections expressed in some groups to the group conceptualizing scientific knowledge and cultural knowledge particularly in relation to Aboriginal Dreamtime. Participants from Maroon cohort recognized that The Dreamtime painting depicted sun, moon and constellations but related astronomy only to scientists like Galileo.

Mr1: The moon in this.
Mr2: It’s a yellow sun.
Mr3: No that’s more like Pluto.
Mr1: How did they know about comets?
Mr2: Astronomy.
Mr1: So that fits in the middle.
Mr3: But that’s only cultural, that’s not scientific. That is definitely cultural.
Mr3: It’s more cultural. It’s Aboriginal Dreamtime.
Mr2: And the sun has a face.
Mr3: Galileo; that’s science. It’s [Dreamtime painting] Aboriginal.

The conflict of cultural groups having a scientific understanding was also extended to bushtucker when a Magenta group was discussing jeeriji/zamia.

Mgi1: What about this thing, this dead tree?
Mgi2: That’s eating.
Mgi3: No that’s like bushtucker. You know bush food.
Mgi1: Bush tucker. That is scientific, how do you know what to eat and what not to eat?
Mgi4: No.

Groups which critically explored scientific and cultural knowledge connections in the Aztec calendar, Zuni proverb and the medicine recognized that scientific understanding and observational skills were required in order to produce such objects or understanding. For example a Maroon participant discussed how calendars have scientific and cultural connections based on a detailed study of the environment over time.
Mr 5: Because it [Aztec calendar] is from the Earth’s rotation around the sun and the Earth rotating around itself which is one day and then around the sun which is one year. And the different seasons from the different ways the solar system is set. I looked at it from a scientific point of view where you look at what happens not will this look nice.

Non-Aboriginal groups rarely mentioned cultural knowledge as a form of knowing and understanding or that cultures practiced their own form of science. In contrast, Aboriginal participants from both Maroon and Quandong cohorts picked up on cultural groups practicing science in relation to the development of traditional medicine.

Mr4: They did not process it and refine it. They just used to have leaves, roots and sap and that and sometimes they would have to take insane remedies.

Participants distinguished between medicine developing from plants as cultural and in the tablet form as science which further reiterates the old and basic, new and improving, culture and science dichotomy.

Mr2: They got stuff from plants and the ground even and they crushed it all together with sticks and rocks to make medicine but science is pills.

**Black people are cultural and Australia is mixed**

Participants associated skin colour with culture, for example, black people are cultural.

MG: Did Tupac sing cultural music?
B2: Yeah. He is a black man. So I am quite sure he is cultural. He is holding a crucifix as well so clearly it is cultural.

How a person looked, their race, and what they were wearing determined if they were cultural for example the Shaman was considered cultural because he looked “ethnic” and was wearing traditional clothes.

ML1H1N1: We have put this one as it looks like some traditional cultures by the headgear and clothes they wearing.
A participant identified Aboriginal culture as Australian culture but was ambiguous about what constitutes Australian culture.

Mgii1: Which cultures?
Mgii2: Australians?
Mgii1: Australia is not a culture.
MG: Australia is not a culture?
Mgii3: Aboriginal is the only culture.
MG: If we exclude for a moment Aboriginal culture in Australia, does Australia have a culture?
Participants: No.
MG: Why do you say no?
Mgii1: Well because like ages ago. Like I don’t know how long ago we were all like immigrants from like anywhere.
Mgii2: No we have many cultures like multicultures but no Australian culture.
Mgii1: We don’t have food or Australian clothes.

Diverse factors can be used to categorise items
Shape, form, function, symbolic representations and creator were strategies that participants used to categorise images. Many groups said that the guitar was made by cultures so represented cultural knowledge and the shoes were scientific because scientists made them. The basket was considered cultural because it was used when making food and food was cultural. For unfamiliar images students would consider what the image resembles. For example with the zebrafish, participants suggested it could be a tie dye painting, an eye or a flower. The soccer ball, wedding dress and guitar were considered both cultural and scientific: wedding dress, guitar and soccer ball require special measurements and materials that use scientific knowledge whilst at the same time music, weddings and sport were cultural events so these items were “used by cultures”.

Symbolism was another approach participants used in categorising. For example GPS - a form of navigation, iPhone - a form of communication, pills- a form of medicine with scientific knowledge and cultural knowledge having equivalents for communication, navigation and medicine.

Mr1: Communication science – smoke signals that is cultural.
Mr2: It is an iPhone how can it go in cultural? It is an iPhone, it is not cultural.
Mr3: No one back in those days had an iPhone.
Mr1: It’s the symbolism of the iPhone. That is definitely cultural.

There was also recognition that cultural groups had their own interpretations of natural processes like lightning.

G1: Lightning in the middle because in the olden days they used to think that the Gods were angry with them and then tz tz tz them.

B4: Many cultures would believe in lightning and the different reasons for lightning.

3.9 Discussion

In this study, young people perceived cultural knowledge as outdated and originating from disparate cultural groups while scientific knowledge was related to modernity, progress, improvement and technology. This is similar to findings in the research reported in Chapter 2 where youth used the words “history” and “ancient” to describe cultural knowledge and “intelligence” and “genius” to describe scientific knowledge. For young people in this study, technology was mainly associated with scientific knowledge and only in very few instances was technology related to cultural knowledge. This is consistent with public historian Steven Conn’s comment that “Nowhere has the connection between science and progress been illustrated more emphatically than in displays of technology…. In science museums, technology is always good and functions as the central actor in human progress.” (2006, p. 502). This presents a challenge to museums that display indigenous technology in exhibits which are often fashioned on historical events. In her study of visitors’ perceptions of the Indigenous Australians exhibition at the Australian Museum in Sydney (Bouman, 2006) found visitors perceived indigenous practices as out of date. She similarly found visitors spoke of the exhibition in past tense despite the exhibit’s objective being to present contemporary Aboriginal society.

Practice theory provides a useful lens with which to analyse young people’s beliefs. Technology, electronics, progress were attributes that were esteemed in discussions about scientific knowledge whilst cultural knowledge was characterized as basic historic knowledge and skin colour. These youth standpoints most likely originate from
a sociohistorical dominance which valorises scientific knowledge and trivializes cultural knowledge in school curricula, mass media and informal education spaces. The tension between scientific knowledge as modern and cultural knowledge as primitive creates negative perceptions and devalues cultural knowledge, setting scientific knowledge as the gold standard against which other knowledge systems are evaluated. The danger of this is the perpetuation of a western world view as dominant and superior and the maintenance of biases and stereotypical essentialist depictions which hinder equity and social justice (Sen, 2012). This is analogous to multicultural societies where the dominant community fails to meaningfully engage with “cultural others” preferring stagnant, ahistorical notions. This was a similar problem for the previously mentioned “Science in India” exhibition at the Science Museum, London where the Indian organizers wanted a progressive representation of India through its rocket and satellite program, whilst the British curators opted for clichéd images such as a bullock cart depicting a stereotypical, poverty stricken India (Sen, 2012).

A compelling finding in this study was an Aboriginal student’s comment on scientists stealing from Aboriginal knowledge. The last decade has seen increased demands for the protection of indigenous knowledge systems, particularly in the area of medicine and the pharmaceutical industry (Recht, 2009). Indigenous knowledge is also informing areas such as ethnoveterinary and environmental management. For example, Bininj/Mungguy traditional ecological knowledge on burning mudja (native grass) is supporting natural resource management and research in Kakadu National Park in Australia (Russell-Smith, et al., 1997). Publicizing past and present Aboriginal contributions to science might help change attitudes to cultural knowledge, decrease perceptions of science stealing from indigenous knowledge and potentially lead to respectful collaboration in use of knowledge.

Informal learning contexts provide intersectional spaces to understand how culture mediates and shapes young peoples’ beliefs and understanding (Teo, 2013). Displays of objects in informal spaces that portray indigenous contributions to science should encourage visitors to consider who created the object, what its function is, what problem it aimed to solve and how it was created. These critical questions are not limited to representations of technology but also to cultural beliefs such as the Zuni proverb or narrative interpretations of lightning. Visitors should understand the potential power of artefacts and cultural interpretations to solve problems, to promote
human thinking and action and to support general application in different contexts. In this way communities can be seen as actors having agency and not passive static entities. By asking critical questions, assessing, interrogating, challenging and negotiating different interpretations intercultural understanding can be realised (Cruikshank, 1995; Trofanenko, 2006).

This meaningful line of questioning aligns with Watson-Verran and Turnbull’s (1995) recommendation, following their work with the Yolngu Aboriginal community in northern Australia, to investigate and present the ways in which knowledge is produced, located, shared and continues to evolve. It resonates with Srinivasan et al’s (2010) reframing of objects not simply as end products but as having their own stories and social existence. Through working with Zuni, a Mexican tribe, they found narratives and stories give objects a shared and situated cultural meaning that improves understanding of those communities (Srinivasan, et al., 2010).

Objects do not speak for themselves nor are they displayed in isolation; they exist in spaces interacting with visitors’ culturally specific identity and knowledge. Visitor identity and concomitantly their group affiliation, values and knowledge is reflected during conversations (Fienberg & Leinhardt, 2012). In our study, young people’s discussions reflected different background knowledge and attitudes. This led to ambiguous knowledge system associations for the wedding dress, guitar and soccer ball. If longer activity time had been possible, narratives about these objects could have encouraged young people to critically consider who created the objects, for what purpose and how.

It was rare to observe sophisticated approaches by young people in this study when they were identifying, analysing or characterising the images presented. In terms of conversational elaboration, participants predominately used level one - listing (what is it?), level two - analysis (what is it like?) and to certain extent level three - synthesis (how does it compare to other objects?). Rarely was the high order critical analysis level four - explaining (why?) demonstrated (Fienberg & Leinhardt, 2012; Leinhardt, Crowley, & Knutson, 2002). Objects can stimulate talk about existing knowledge and understanding that can open the door for new knowledge to be integrated during discussions. Narratives about objects offer a useful approach in which to present historical and social contexts and stimulate conversation. Narratives go beyond
describing simple physical features but illustrate the uses of the object and the lived experiences in which the object was embedded; this helps people make sense of the object. Narratives in informal spaces have been found to be powerful in encouraging meaning making and promoting understanding of difficult concepts (Stocklmayer, et al., 2010). It is unfortunate that in our study we did not provide an opportunity for participants to share stories about objects that exist in the science and culture interface in their or other cultures. This is something that would be interesting to explore in follow-up studies.

This study looked at Aboriginal and multicultural representations. Often Aboriginal themes are separated from issues of multiculturalism. In this study they were combined under the umbrella of cultural diversity as separating them may perpetuate notions of otherness and create divisions of Aboriginal people, white Australians and cultural others. Young people in our study often referred to “cultures” as a set of people, with skin colour as a feature attributed with “cultures” (e.g. Tupac and black people). This suggests that the young people in this study who represented over 30 ancestries nonetheless subscribed to the pluralistic stereotypic definition of culture which uses token strategies to essentialise culture based on skin colour (Seiler, 2013). Hutchinson (2009) in her development of an exhibit on multiculturalism titled Migration Memories at the National Museum of Australia, suggested a more fluid approach to diversity, away from diversity as a “collective noun” which “operate[s] as a perfect managerial term in that it objectifies and makes passive”. Similar to Seiler’s view, Hutchinson attempts to recast diversity as a verb promoting interaction and exchange between groups. Instead of objects representing ethnic material culture, the objects in Migration Memories were sourced from individuals and were placed in context of stories; for example a jean t-shirt worn by a Cambodian migrant tells the story of conflict and history in Cambodia. As an analogous approach relating to science and culture, what story could a sari (clothing worn in South Asia (e.g. India, Pakistan, Nepal) and which has been appropriated by western fashion) tell about science and cultural diversity?

Intercultural understanding starts from valuing one’s own culture. Young people’s identification of their own cultural identities was limited as demonstrated by mentions of the absence of a distinct Australian culture. In a study of youth beliefs about what it means to be Australian, diversity was recognised as one of the characteristics of Australia (Purdie & Wilss, 2007). Interestingly the Purdie and Wilss study also found
that scientific and intellectual endeavours were absent from conceptions of an Australian identity. National identity in Australia is a problematic subject and is often put in opposition to multiculturalism (Moran, 2011). A strong national identity facilitates social cohesion and eases adaptation in times of hardship (Moran, 2011). The challenge in Australia is to create a national identity that is representative and inclusive of migrants, that is adaptable to change and recognises and respects Aboriginal people as the first people of Australia. Museums as authoritative institutions that represent national identities have a crucial role to play in this endeavour.

3.10 Conclusion

We began this chapter by arguing that representing the connections between scientific and cultural knowledge can provide a platform in which intercultural understanding can be inspired in multicultural contexts. Based on our findings, we suggest that scientific and cultural knowledge representations in informal spaces portray current and past cultural knowledge practices that include the development of technology. Representations should also demonstrate how knowledge adapts, evolves, is influenced by a number of factors and how scientific and cultural knowledge contribute to and learn from each other. Representations could be spread across a number of diverse and overlapping cultures in areas such as mathematics, engineering, natural resource management, medicine, architecture and social activities (Onwu & Mosimege, 2004) and should be respectful of spiritual connections. Narratives about objects in informal spaces provide a pathway for inspiring intercultural understanding. The desired outcome is people as global citizens who acknowledge and value their own and other’s cultures.
Preface

In Chapter 3, we described young Australians’ beliefs about scientific and cultural knowledge and a role for representations and narratives of objects in promoting understanding of culture. In the next chapter, we investigate student-generated films about science and culture and the potential for filmmaking to support engagement with science learning and encourage intercultural understanding. Funds of knowledge is used as the framework to engage students and support connections between science and culture. Three schools, two in Western Australia and one in Malawi participated in the filmmaking program. The difference in findings across the three schools reveals factors that contribute to student engagement with science. We discuss the role and effects of incorporating funds of knowledge and filmmaking in multicultural science classrooms.
4 Bridging science and culture through youth generated films

4.1 Abstract
This research project investigated whether student-generated films about science and culture bridge home and school worlds, what funds of knowledge students draw on and to what effect?

We begin our discussion by describing the complex landscape of multicultural science education in Australia and Malawi. This leads into a review of frameworks: funds of knowledge, third space and hybrid spaces that attempt to support intercultural science education. We built on the concept of funds of knowledge, adding the beneficial learning process of filmmaking. With both in mind, we developed a three-week science and culture filmmaking program that was implemented in two schools in Western Australia and one in Malawi. The program involved teams of 69 students making 39 films of their interpretation of science and culture. As part of the program, students were trained in storyboarding, camera operation, editing and were permitted to take a camera home for filming. At the end of the program, students’ films were shown at a community screening that was open to family, friends and staff.

Qualitative analysis of observations, students’ films and student and teacher interviews examined the effect of using videos to incorporate funds of knowledge in class. We discuss ways in which students at the different schools drew on personal, peer, family and community, school and popular culture funds of knowledge as they made their films. Students experienced a sense of empowerment and demonstrated an awareness of the connections between science and culture. We further note the role of student-generated films in facilitating intercultural understanding in multicultural classrooms.

4.2 Introduction

4.2.1 Multicultural science education
Australian classrooms are becoming increasingly culturally diverse, with one in every four Australians born overseas and immigrants identifying with over 270 ancestries (Department of Immigration and Citizenship, 2011). This cultural diversity as well as
Australia’s rich Aboriginal history is a valuable social, linguistic and cultural resource. Students come to school with knowledge of their home and community environments; however this wealth of information is often not valued in the classroom (Gonzalez & Moll, 2002). Teachers who are mainly white Australians may be ill-prepared to cope with or leverage this multiplicity of cultures and experiences that students bring to the classroom (Kamler, Santoro, & Reid, 2001).

A survey of 345 teachers and administrators at 10 schools in New South Wales found that 22% of the teachers perceived that once a student is able to speak English, then no further cultural integration is necessary (McInerney, 2003). Proficiency in English is important for educational achievement; the results of the 2009 Programme for International Student Assessment (PISA) found that Australian students with a language background other than English performed significantly poorer than students who spoke English as their first language (Thomson, De Bortoli, Nicholas, Hillman, & Buckley, 2010). There are many factors that contribute to this, as discussed below.

In general, first generation Australian students perform better in international assessments than Australian born and foreign born Australian students (Thomson, et al., 2010). When compared to immigrants in other western countries, Australian immigrants perform better (Dronkers & de Heus, 2012), but this may be compounded by a large percentage of immigrants in Australia born in the United Kingdom (20.8%) and New Zealand (9.1%) who more easily assimilate in Australia (Australian Bureau of Statistics, 2012; Dronkers & van der Velden, 2013).

Unfortunately data that break down Australian student science performance by country of origin are not available. Such data may highlight biases that favour outcomes for students who originate from countries with education systems, socio-economic development indices and Western cultural orientations which are similar to Australia.

Data from PISA 2009, which measures scientific literacy through assessment tasks, reveals that in comparison to foreign born students, Aboriginal students fare worse in scientific literacy, lagging an equivalent of two full schooling years behind their non-Indigenous counterparts and foreign-born students (McConney, et al., 2010; Thomson, et al., 2010). To a certain extent immigrants and Aboriginal people experience similar poor education, economic and social outcomes (Koleth, 2010). But at a policy level,
attempts to include Indigenous issues within multicultural policies have been controversial. Academics have cautioned that including Indigenous issues within a multicultural context negates Aboriginal people as the first people of Australia and ignores the tragic historical origin and factors that cause the social, historical, political and economic hardships that Aboriginal people experience (Tavan, 2006).

Acknowledging the complex landscape, this research is concerned with cultural inclusivity in the classroom. Our aim is to draw on the culturally rich backgrounds of all students, including Aboriginal, foreign born and non-indigenous Australians. We observe that classrooms, particularly in regional and metropolitan areas where a majority of the population lives, are culturally diverse and policies that make distinctions along ethnic lines perpetuate a sense of otherness, alienation and a “them and us” attitude. We report on a specific classroom activity – student produced films about science and culture – that was designed to engage students from all cultural backgrounds. In development of this activity, we considered that factors affecting many foreign born and Aboriginal students’ performance in science can be similar: socioeconomic disadvantage (Dronkers & van der Velden, 2013); time spent on science lessons and study outside of school; teaching style and characteristics of science teachers such as understanding of Aboriginal culture and history and interacting with students outside of class, (Harslett, Harrison, Godfrey, Partington, & Richer, 2000; Woods-McConney, et al., 2011); and students’ attitudes, engagement, motivation and beliefs (De Bortoli & Thomson, 2010).

Research studies show many students report they do not like science because they perceive that it bears no relevance to their personal experiences (Basu & Calabrese Barton, 2007; Elmesky, 2005; Zimmerman & Bell, 2012). Often students equate science to Einstein, lab coats and goggles and fail to see themselves or the knowledge within their own communities as examples of science (Basu & Calabrese Barton, 2007; Bouillion & Gomez, 2001). Basu and Calabrese Barton (2007) suggest that this disconnect is one reason why students fail to engage deeply with science.

Contextual factors that influence science performance in Australia also affect students in Malawi, Africa (Chimombo, 2005). Unfortunately no comparable PISA or Trends in International Mathematics and Science Study (TIMMS) data is available for Malawi. Furthermore Malawi with a GDP of $4.2 billion USD in comparison to Australia’s $1.5
trillion USD (World Bank, 2013) puts them at extreme ends of the economic development spectrum which may suggest no meaningful comparison can be made. However, a Malawian school was included in the study because one of the authors is from Malawi and had access to a school. More importantly, if Malawian students in a multicultural classroom experienced similar benefits from the science and culture filmmaking program this would provide further evidence for the value of using filmmaking to engage students in a broad range of contexts and science classrooms.

In addition, a number of previous multicultural science education approaches have focused on homogenous classrooms (Morrison, Robbins, & Rose, 2008) for example African American (Boutte & Hill, 2006) or Latino/a (Moje, et al., 2004) or other ethnic minorities (Tsurusaki, et al., 2013) and on specific topics e.g. nutrition (Tsurusaki, et al., 2013) or music (Elmesky, 2005). We therefore attempted a practicable strategy which would inclusively draw on all students’ cultural backgrounds and would be implementable in many types of classrooms and on any subject.

A number of strategies exist to facilitate equity in diverse classrooms: culturally relevant pedagogy (Ladson-Billings, 1995), multicultural education (Banks, 1995), and funds of knowledge (Moll, Amanti, & Gonzalez, 2005). However most teachers perceive culturally responsive teaching to only be relevant to language and social studies; science is often ignored in the context of culturally responsive teaching (Boutte & Hill, 2006). This gap in culturally responsive science teaching places students at risk of not developing scientific identities. If students fail to locate themselves within society, they may not consider possible future careers and may have a less appreciable engagement with subject matter that could be inspirational (Calabrese Barton & Tan, 2010; Witz, 2000).

Several benefits of creating strong links between the science classroom and students’ homes have been documented: i) students are more enthusiastic about learning science (Aikenhead, 2001); ii) scientific knowledge is understood better and retained for longer (Upadhyay & DeFranco, 2008); iii) students are more engaged in the science classroom (Hammond, 2001); iv) students maintain an interest in science (Basu & Calabrese Barton, 2007); v) students feel empowered which leads to more self-directed learning of science (Salter, 2013; Tsurusaki, et al., 2013).
This chapter addresses issues of equity in science learning by contributing important observations about incorporating funds of knowledge in the science classroom. A concrete classroom practice is described which uses student-generated films in integrating funds of knowledge in the science classroom. We examined the topics of the films students produced, the funds of knowledge that students drew on, effects that producing and viewing these films had on students and some of their family members and discuss whether filmmaking empowers students and potentially engages them in science learning.

### 4.2.2 Funds of knowledge

Funds of knowledge are “historically and culturally developed bodies of knowledge and skills” (Moll, Amanti, Neff, & Gonzalez, 1992, p. 133). Use of funds of knowledge is a pedagogical approach incorporating students’ home and community culture in the science classroom, for example students’ use of street language in the science classroom (Tan & Calabrese Barton, 2010). This teaching strategy facilitates students’ recognition that their families and communities practice science on a daily basis, even though they may or may not label it as science. It recognises that “…people are competent and have knowledge, and their life experiences have given them that knowledge” (Gonzalez & Moll, 2002, p. 625). Incorporating funds of knowledge in teaching builds bridges and explicitly values students’ home experiences in the classroom. Examples of funds of knowledge include historical and accumulated cultural knowledge of hunting animals, star navigation and traditional medicine.

Moll et al (1992) conceptualized funds of knowledge as an approach to capitalize on the knowledge and skills within Mexican communities in Arizona, USA. The researchers wanted to go beyond the didactic teaching normally given in classroom to provide students with rich relevant learning experiences. In their ethnographic study, researchers and teachers visited students’ homes and communities to document funds of knowledge available to students. Their findings suggest that it was both useful and feasible for teachers to visit students’ homes. The research gathered from teachers’ home visits can support the development of student research teams where students can investigate issues that are important to them or are part of achieving learning outcomes.

Funds of knowledge can be used to improve equity and explicitly demonstrate respect for the learner. Linking science to community activities can empower students to see
science as accessible and relevant to their everyday lives (Hammond, 2001). A study on teaching for social justice in a low-income, immigrant, ethnic minority community in the US found that allowing students to bring their funds of knowledge into the science classroom improved student learning and enjoyment of science (Upadhyay, 2010).

Several researchers have documented students’ improved learning outcomes when funds of knowledge are incorporated in science teaching (Calabrese Barton & Tan, 2009; Cowie, Jones, & Otrel-Cass, 2011; Elmesky, 2005; Nashon & Anderson, 2013; Risko & Walker-Dalhouse, 2007; Tsurusaki, et al., 2013). An ethnic minority teacher in the US was able to draw on community funds of knowledge in a school garden project in which parents, teachers and students worked together (Upadhyay, 2009). A funds of knowledge approach saw inner city African-American youth talking about science in new ways and demonstrating both depth and breadth of scientific understanding during a lunch club (Seiler, 2001). Incorporating Maori cultural knowledge of mountains in a landforms unit in New Zealand led to students developing science identities and teachers having a deeper understanding of their students (Cowie, et al., 2011). In Uganda, higher performing schools were found to be more likely to use students’ everyday knowledge in the science classroom (Sikoyo & Jacklin, 2009). Funds of knowledge approaches are not limited to science. Reviews of funds of knowledge have identified up to 50 texts that discuss funds of knowledge strategies in science, language arts, literacy, social studies, history, and mathematics (Hogg, 2011; Rodriguez, 2013).

Funds of knowledge enable teachers to use diversity and students’ communities as rich resources for teaching as well as to support student, family and community engagement with school. Following his work with the Hmong, an Asian ethnic minority, in an urban school in America, Upadhyay stated that

> teaching science to empower underrepresented students relates not only to classroom engagement but also to community and family engagement. Students who see their community and family members interact and engage in science come to understand that science has a place at home, and that they need to learn science to improve their chances for future success. (Upadhyay, 2009, p. 230)
In the context of funds of knowledge, Discourse is defined as ways of knowing, reading, writing, valuing, interacting, doing, representing oneself and talking that are embedded within sociocultural practices as postulated by Gee (1996). The integration of multiple funds of knowledge and Discourses at school helps pupils learn and navigate both at school and beyond (Moje, et al., 2004; Risko & Walker-Dalhouse, 2007). Moje et al (2004) categorise funds of knowledge under family, community, peer groups and popular culture. Similar to other findings, they found that family funds of knowledge were mainly based around the work that parents did at home (domestic activities like cooking and cleaning) and in the workplace (Gutierrez & Rogoff, 2003). In a survey asking practicing scientists in Australian and New Zealand what motivated them to study science, parents were cited as a moderate influence (Venville, Rennie, Hanbury, & Longnecker, 2013). Community funds of knowledge centred on strong ethnic identity with advocacy and social activism translating into youth enacted funds of knowledge. Peer funds of knowledge and Discourses were important for how to “do” school i.e. through language, informal peer activities like stunting on bikes and formal peer activities like car clubs. Popular culture funds of knowledge and Discourses, particularly music and teen magazines, were the most dominant fund that youth engaged with (Moje, et al., 2004).

Many students are skilled and strategic in their use of funds of knowledge. They demonstrate they are aware of appropriate discursive moves and language, by using them according to audience and purpose (Calabrese Barton & Tan, 2009; Moje, et al., 2004; Risko & Walker-Dalhouse, 2007). For example, youth draw on popular culture more than any of the other funds or personal experiences when discussing issues related to science (Calabrese Barton & Tan, 2009; Moje, et al., 2004). When students discuss music and other funds of knowledge, they inherently draw on a specific set of discursive tools. These skills can be harnessed for learning science by using funds relevant to some cohorts such as African American hiphop culture (Emdin, 2010). Interventions that incorporate popular culture funds of knowledge in the science classroom may provide an avenue to address Morrison, Robbin and Rose’s observation (2008) of a lack of classroom strategies that target heterogeneous multicultural classrooms.
4.2.3 Third (Hybrid) space

The concept of third space draws on funds of knowledge. Moje et al (2004) use the term third space to describe the merging of knowledge and Discourses from the first space (people’s homes, peers and community) and the second space (institutions such as church, school and work) into something new. Moje et al (2004) adopt Moll, Amanti, Neff, & Gonzalez’s (1992) “funds of knowledge” as knowledge that has been acquired over time and space, is culturally relevant and whose purpose is to support day to day living, well being, household functioning and development. The third space draws on students’ funds of knowledge, teachers’ use of this knowledge and making of new meanings. Moje et al (2004) draw on three views of a third space. One view posits third space as the bridge between traditionally marginalized funds of knowledge and academic knowledge. In a second view, the third space is where one can successfully navigate the different Discourse communities. A third view is where Discourses are brought in to challenge and reshape the dominant school Discourse.

For Wallace (2004), third space is a pedagogical strategy between teacher and learner which embraces and leverages the student’s familiar language in creating scientific meaning,

an abstraction of a space/time location in which neither the speaker's meaning nor the listener's meaning is the ‘correct’ meaning, but in which the meaning of the utterance is hopeful for either co-construction of interpretation or new hybrid meanings. (Wallace, 2004, p. 908)

In other words, third space is where different languages, beliefs and experiences, are neither dominant nor privileged and can coalesce to create new meanings.

A simple reading of Gutierrez’s (2008) conceptualization of third space includes classroom environments where students’ cultural and socio-political histories are validated and students’ possible futures are imagined. Gutierrez (2008) expanded on the concept of third space to include social interaction, “students link the past and present to an imagined future and reorganize everyday concepts acquired through social interaction in joint activities into scientific or school-based concepts” (p. 158). The third space creates a space where dominance, power and privilege can be challenged, transformed and liberated (Shumar, 2010).
These multiple meanings of “third space” are all premised on Bhabha’s hybridity theory (2004) which asserts that people draw on a number of resources or funds in order to make sense of the world. A drawback of third space is its fluidity - non-permanence, chaos and the sense that knowledge is not constructed (Wallace, 2004). As a theory it is limited to philosophical approaches which fundamentally ask teachers to critically rethink how they teach but provide little in actual classroom strategies that teachers can implement (Flessner, 2008). In practice, scholars have used third space as a theoretical lens in which to understand a range of situations from how nursery aged children created third spaces between home and school (Levy, 2008) to how science curricula can be inclusive of indigenous knowledge (Glasson, et al., 2010).

In one example in Malawi, Glasson et al. (2010) found that teachers failed to capitalize on elders in a community holding an extensive knowledge of traditional sustainable farming practices including why the practices were superior to western ways of farming. Teachers instead taught indigenous students less relevant western scientific examples. In that situation, local knowledge on sustainable farming could serve as a rich resource for creating a third space.

Barton and Tan (2009) combine funds of knowledge, Discourses and Moje’s third space and use the term ‘hybrid space’. They studied the funds of knowledge and Discourses that students brought to a 6th grade unit in food and nutrition in a low-income urban middle school in the United States. They categorized their funds of knowledge and Discourse findings similar to Moje et al.’s categories: family, community, peer and popular culture. Key Discourse threads across the categories were in family funds – family traditions in cooking, diet and ethnic diversity, in community funds – fast food, in peer funds – talents and interests and in popular culture funds – music, fashion and television.

4.2.4 Limitations of funds of knowledge

Moje et al.’s (2004) study discusses at length funds of knowledge to support bridge building between spaces (home and school) but is not clear about how building bridges differs from creating a third space (for relevant discussion see 2.2.5 in this thesis). Furthermore, Moje et al. (2004) describe how students’ engagement in third spaces
might impact student identities and concomitantly influence student performance, but they do not theorise how.

Another concern of the funds of knowledge approach is the potential simplification of complex socio-political issues in the science classroom and the risk of ignoring the complex interplay of historical power and dominance (Bourdieu, 1991). An example would be discussing Aboriginal knowledge without recognising the conflicts caused by European settlement and the prohibited use of language and culture by children taken into custody and placed in state or mission care. In addition, funds of knowledge can cause confusion in multicultural classrooms. In Upadhyay’s study (2009) a non-Hmong student was perplexed by the teacher’s explanation of herbal remedies to cure coughs and colds and conversely a Hmong student was not familiar with Pepto-Bismol (a drug that treats upset stomachs) and thought it was a plant.

Funds of knowledge suggest incorporating cultural knowledge is the only way of achieving equitable science education for communities. This approach disregards that students can find science interesting and worth pursuing, regardless of whose cultural values are embedded in science teaching. In Carlone and Johnson’s (2012) longitudinal study of Latino primary school students, one girl’s identity performance was consistent whether or not Latino cultural values were included in the classroom Discourse. Another risk of emphasizing local knowledge is students feeling confident in one setting but in actual fact being ill prepared for other contexts or for university (Johnson, 2007). We proffer that there is no magic bullet or one size fits all approach for achieving positive educational outcomes for all students but suggest that programs designed to benefit minority groups can also benefit dominant groups.

Funds of knowledge are an education resource. In order to achieve equitable outcomes for students, use of funds of knowledge requires implementation through purposefully designed activities. We propose student production of films as an activity that can support and validate the inclusion of funds of knowledge in the classroom.

### 4.3 Student-generated films

The research literature is replete with examples of the beneficial educational outcomes arising from student-generated videos. Kearney and Schuck’s (2005) case study of
student-generated videos in two primary and three secondary schools in Australia found a number of beneficial learning outcomes: improvement in literacy skills including visual, media and technical skills; enhanced communication and presentation skills such as narrating and interviewing; increased organization and teamwork skills including leadership and negotiation, enhanced high-order thinking skills such as problem solving and reasoning; knowledge of movie making skills like editing and storyboarding; and positive impacts on affective domains such as self esteem, confidence and responsibility.

A study of 50 schools in the UK found that student-generated video increased engagement and enabled different learning styles (M. Reid, Burn, & Parker, 2002). Digital video production engaged students with content in more depth than did traditional writing projects (M. Reid, et al., 2002). Filmmaking also provided opportunities for reflection, cross curricular integration (Kearney & Schuck, 2006), opportunities for collaborative learning, student voices and ownership (Furman & Calabrese Barton, 2006) and creative expression of ethical, political and historic issues (Elmesky, 2005).

Dating as far back as the 1980s, video has been found to be an effective tool for working with less confident young people who often may have been labelled or see themselves as failures (Dowmunt & Berman, 1980). Video production is a way of motivating reluctant or disengaged learners (M. Reid, et al., 2002). The Stride Foundation, along with a growing number of Australian organizations, uses video as a tool to engage at risk youth in schools in low socio-economic areas (Stride Foundation, 2012). Particularly for Aboriginal students, the flexibility of the technology supports sensitive portrayal of personal contexts and cultural difference, offering students an opportunity to express themselves (The Smith Family, 2008). The versatility of video allows multiple forms of expression as demonstrated by Elmesky’s (2005) work with African American students who helped produce a video on the physics of sound which used a variety of artistic forms including rap and dance. Student-generated video projects give students voice and ownership which cultivates a sense of agency; this sense of agency empowers students which can inspire them to learn science (O’Neill & Calabrese Barton, 2005).
An authentic audience of family and peers such as at community screenings of student films further motivates students (Kearney & Schuck, 2006). Students place a greater value and produce a better product when there is an authentic audience compared to assignments when the teacher is the only person who will view their work (Longnecker & Gondwe, in press).

During the process of filmmaking, students act as researchers, authors, designers and writers. As researchers, students identify and select the information that they will present. As authors, students consider their intended audience and what information is relevant. As designers, students select the visual and audio media to convey their story. As writers, students select and fit the information, linking it with visual and audio media.

Education policies and curriculum guides promote the use of ICT (Dawson, 2008) and student-generated video and their subsequent beneficial learning outcomes (Hofer & Owings-Swan, 2005). However, despite the easy access to cheap recording equipment and user friendly drag and drop editing tools that make desktop production of films feasible, the uptake of student-generated videos in classroom is poor and there are only a limited number of research studies assessing the theoretical framework of filmmaking (Henderson, et al., 2009; Hofer & Owings-Swan, 2005).

We draw on the benefits of student-generated videos and funds of knowledge to investigate whether films produced by students can connect science (school) and culture (home) worlds. Filmmaking gives students an opportunity to use their own voice and to share their stories. Additionally, filming in their homes provides students with an opportunity to involve their family. By researching, documenting and sharing their own stories of science and culture, students can develop positive scientific and cultural identities and take pride in their cultures. This paper addresses the following research questions:

- Are student-generated films about science and culture able to connect home and school worlds?
- What funds of knowledge do students draw on and to what effect?
4.4 Method

A case study of three schools explored the use of student videos for including funds of knowledge in the classroom. Case studies provide a rich understanding of complex phenomena (Yin, 2003). Through purposive sampling of schools, we selected three schools with different ancestral compositions (Table 4.1): one cohort comprised Aboriginal students in a regional area of Western Australian, a second cohort comprised students in a culturally diverse school in the Perth metropolitan area, the third cohort was a class of students at a culturally diverse Malawian school with some foreign born students. All the cohorts participated in the study in 2011. Names of students, teachers, coordinators and schools are replaced with pseudonyms.

4.4.1 Participants

School Rainbow

School Rainbow was selected because of its large cohort of students with a language background other than English (42%), with a student body speaking 54 languages other than English. During the first meeting with the Principal he remarked on the school’s philosophy of embracing cultural diversity. He further elaborated on this by pointing to a pull-up banner in the main reception that explicitly described the school as welcoming of all cultures.

A Year 7 class of 30 students participated in the program. Because the 2011 Year 7 class was a larger than normal cohort, they used two adjoined classrooms with an open divider. In 2011, the Year 7 class was taught by a stand-in Year 3 teacher. Miss Peacock had been asked to coordinate the Year 7 class that year because she had demonstrated the ability to manage a large class size. She had taught at School Rainbow for six years. The school had a high rate (approximately 50%) of student transience with very few students entering at Year 1 completing Year 7. The neighbourhood is attractive to a number of first arrivals to Perth because of its proximity to the CBD and relatively affordable accommodation but most families move on after a year or two of living in the neighbourhood.

The ancestries of the students that participated in this study were diverse, including Europe, Asia and Africa (Table 4.1). The surrounding neighbourhood is a multiethnic
neighbourhood with a mixture of socioeconomic classes. The shops on the main high street, ten minutes from the school, portray the cultural mix of the neighbourhood, with an African hairdressing salon, a Chinese food market, a Turkish kebab take away, a Thai restaurant, an Indian curry house, an Italian hair stylist and an Italian coffee shop.

Table 4-1
Description of study participants and data collected.

<table>
<thead>
<tr>
<th>School</th>
<th>Description</th>
<th>Number of students</th>
<th>Year level*</th>
<th>Number of videos</th>
<th>Film topics</th>
<th>Number of interviews</th>
<th>Ancestries</th>
</tr>
</thead>
<tbody>
<tr>
<td>School Quandong</td>
<td>GPFF* regional, Western Australia</td>
<td>18</td>
<td>Yr 7-9</td>
<td>11</td>
<td>Hiphop dancing, guitars and music, parkour, family roles, grandmother, favourite place, Follow the Dream program, Dreamtime ghost story, hunting</td>
<td>12***</td>
<td>Aboriginal, Australian, German, Irish, New Zealander</td>
</tr>
<tr>
<td>School Nyasa</td>
<td>Malawi regional</td>
<td>21</td>
<td>Yr 9</td>
<td>18</td>
<td>nsima (food), traditional and modern dancing, drumming, capoeira (flips), experiments, environment, deforestation, water pollution, ducks, flowers, trees, forces and friction, cats and drugs, water cycle</td>
<td>14</td>
<td>Malawian, Indian, Iranian, Pakistani, Zimbabwean</td>
</tr>
<tr>
<td>School Rainbow</td>
<td>Perth – Metropolitan, Western Australia</td>
<td>30</td>
<td>Yr 7</td>
<td>10</td>
<td>fireworks, Batman, Aboriginal history, coffee, pap (food), basketball, kung fu, spinning tops, drumming and music</td>
<td>10</td>
<td>Aboriginal, Australian, Ethiopian, Japanese, Kenyan, Libyan, Malaysian, New Zealander, Romanian, Serbian, South African, Thai, Ukrainian</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>69</td>
<td></td>
<td>39</td>
<td></td>
<td>36</td>
<td></td>
</tr>
</tbody>
</table>

*GPFF = Graham Polly Farmer Foundation.
**Year 7 = 12-13 years of age, Year 8 = 13-14 years, Year 9 = 14-15 years
*** There are 12 interviews and 11 films because an interview was conducted with a student who did not finalize production of his film.
A number of Aboriginal people congregate in the park near the community centre. Also in the neighbourhood is a Buddhist temple and community organizations for people from Bulgaria, Poland and Sudan.

The school had participated in the “Primary Connections: Linking science with literacy”. Primary Connections is a program that was developed by the Australian Academy of Science to improve teacher’s ability to confidently teach science (Hackling, 2006). School Rainbow also participated in a Department of Education pilot program targeted at high achieving Aboriginal students from Year 3 through to Year 7. In 2011, one of the teachers won the Science Educator of the year award. She was recognized for using innovative approaches like cartoons and puppets to engage students and developing activities that supported different cultural backgrounds and learning styles. The school, however, had no fitted science teaching laboratory. For science class the Year 7 students used the back half of the adjoined classroom. Science equipment, which included everyday items like candles and compasses, was kept in portable plastic storage containers. Students had varying exposure to filmmaking as a few students in Year 6 made television advertisements as part of an information technology class.

**School Quandong**

School Quandong is a regional Western Australian high school located in a mining area. The Follow the Dream (FTD) Graham Polly Farmer Foundation (GPFF) after school homework program for aspiring Aboriginal students at School Quandong were invited to participate in the study. Graham Polly Farmer Foundation is a project partner on the Australian Research Council Linkage grant (LP100100640) that funded a PhD scholarship and hence the research reported in this thesis. The aim of the Follow the Dream program is to help aspiring Aboriginal students graduate from high school and achieve tertiary level entry or employment. The program operates in regional and metropolitan areas. In 2010, the program had 486 students in 15 centres across Australia (The Graham (Polly) Farmer Foundation, 2010).

A four year longitudinal study found Follow the Dream had been successful in: retaining Aboriginal students in school through to year 12, assisting students to graduate
from high school, supporting students to pursue further education, gain employment or achieve vocational training (Partington, et al., 2009). The success of the program has been attributed to caring coordinators, tutorial assistance, enrichment activities like camps and university visits and recognition of the role of parents and guardians (Partington, et al., 2009).

Students are invited into the program based on their National Assessment Program – Literacy and Numeracy (NAPLAN) scores. NAPLAN is a national benchmark test given to students in Years 3, 5, 7 and 9. Students are assessed on reading, writing, language conventions (spelling, grammar and punctuation) and numeracy. Principals and teachers may recommend students with low NAPLAN scores but students must have demonstrated learning potential. Parents can also apply for their child. Each Follow the Dream program is staffed by a full time program coordinator who reviews applications, tracks student progress with teachers and parents, organizes daily snacks, hires tutors and arranges extension activities.

School Quandong has two Follow the Dream programs, the Years 7-9 who meet on site at the school and Years 10-12 who meet at a site off school. The program runs Monday to Friday for two hours after school and students are required to attend at least twice a week. The intake for the Years 7-9 program in 2011 was 40 students. Students came to the program immediately after school ended. Upon arrival they were given food, then tutors assisted them with their homework. Tutors, mostly recruited from teachers at the school, provided students with one-on-one assistance. A bus took students home at the end of each daily session. The Follow the Dream program coordinators also organized extension programs, camps and invited guest speakers. In 2011, Ms. Carr, the coordinator for the Years 7-9 Follow the Dream program had been managing the program for three years. She had a close relationship with the students and knew their parents and guardians well. Her office was located in the school. She was designated as school staff and thus had access to student records to monitor student academic performance.

Eighteen students from School Quandong’s Follow the Dream program participated in the research activities reported here; because of extracurricular engagements like sport and dance and no requirement for students to attend the Follow the Dream program daily, there was variability in student attendance during the days the research activities
were conducted. A few students had some experience with filmmaking through the school’s media education program.

**School Nyasa**

School Nyasa is a private boarding and day school located in one of the main urban centres in Malawi. The school was established in 2010 as the premiere international academy of excellence for the region. In 2011, there were approximately 90 students. The faculty were mainly Malawian with a few from America and Europe including the headmaster who was from the UK. The school is part of a foundation that also supports a community based organization for widows, women on low incomes, children orphaned by AIDS and other vulnerable children. The school offers scholarships to children from disadvantaged backgrounds. Students offered scholarships are selected from children who are involved in the foundation’s community programs. These competitive scholarships require students to demonstrate academic potential and hard work.

School Nyasa’s fees were USD $510 which by Malawian standards can only be afforded by middle to high income families (GDP per capita in Malawi is $902 (World Bank, 2013). This meant that the school had students from both low (scholarship recipients) and high (fee paying) socioeconomic backgrounds with the majority being fee paying students who lived in the low density suburbs of the city.

English is Malawi’s official language and is the language of instruction at School Nyasa. Almost all the students spoke the national language, Chichewa, however students were strongly encouraged to speak English outside of lesson times such as during recess and lunch. Malawi has a considerable number of people of Asian and Middle Eastern descent (particularly Indian, Pakistani, Bangladeshi and Lebanese). A number of the shops in the city centre were owned by Asians with an increasing influx of people from Burundi and Rwanda. The city with a population of 168,000 was experiencing rapid annual growth of 4.2% (UN Habitat, 2011). A number of commercial buildings, banks and offices were under construction during the time of the study. The city centre had a number of offices for non-governmental organizations, government offices, markets, take-away restaurants, hardware stores, photocopying, stationary shops and internet cafes. The city is renowned for a market that sells second
hand and new clothes and fabric. A majority of Malawi’s population is Christian (83%) followed by Muslims (13%) (National Statistical Office, 2009). The school recognised all religions but observed Christianity; Christian prayers were said at assembly and before meals in the cafeteria. The school also provided transport to church on Sunday for boarders.

The school is located 15km away from the city centre in a relatively remote and quiet wooded area. A bus collects and drops day students off in the city. The boarders were also provided transportation back to their boarding house. The boarding facilities were under construction at the time of this study and two houses were rented - one for boys and one for girls.

The school follows the British National Curriculum which leads to the University of Cambridge International General Certificate of Education (IGCSE) in Year 11 and Advanced 3 Level Studies in Year 12. The Year 9 class was using British Key Stage 3 textbooks and modules. Mr. Nyirenda, the science teacher and deputy Headmaster had 11 years experience teaching science and had been at the school for less than a year. The previous science teacher, Ms. England, was a young teacher from the UK. The school facilities were mostly new and of a good quality. For example the computer lab had 20 brand new Dell computers. The students at this school had no exposure to filmmaking and had varied levels of computer skills.

4.4.2 Filmmaking workshop

The first author (MG) facilitated all of the filmmaking workshops. Cameras and tripods were provided by the research project for students to use during the workshop. The schools provided computers for editing. At School Rainbow the free program Pinnacle Video Spin was installed for student use; at School Quandong, the coordinator purchased licenses for Adobe Premiere Pro for laptops used by students in the program and at School Nyasa students used Windows Live Movie Maker. MG gained proficiency with each program to be able to assist students with editing.

The filmmaking workshop introduced storyboarding, camera and tripod use, film techniques, different shot types, and editing (Appendix 2). Students were permitted to take cameras home or to the boarding house to film. Student films were shown during a community screening where staff, parents and friends were invited. Certificates of
completion and a DVD copy of students’ films were also given to students at the screening. The activity in each school lasted about three weeks with workshop sessions running either for 40 or 80 minutes a day. The first week focused mainly on technical skills and story development. In the second week students filmed and the final week students edited and then films were shown at a screening (Appendix 3).

The contexts of film production were different at each school but in all instances students were told the films were limited to three minutes and were to be about their interpretation of science and culture. At School Rainbow group films were made during science and general classes. At School Quandong individual student films were produced as part of an after-school homework program. At School Nyasa individual student films were produced as part of science and information technology classes. Reasons for differences in delivery mode were timetable constraints, limited access to the specific participant group and availability of equipment. For example in School Rainbow, there were thirty students and only nine video cameras and so students worked in groups.

Students were given as much control as possible in choosing the topic, designing and producing their films. Students had the freedom to choose the topic of their film as long as it related to their interpretation of science and culture. By giving students control of topic and content, we hoped to explore the topic they chose, the motivation behind their choosing such topic and how they constructed science and culture. Because this research examined how students looked at science and culture and drew on funds of knowledge, the students were provided only limited support in identifying topics and were encouraged to research the connections on their own.

### 4.4.3 Data collection

This study was informed by multiple sources of data: reflection notes and observations, interviews of students and teachers, student think-alouds and films. Multiple data sources enabled triangulation which improved rigour and trustworthiness of findings (Leech & Onwuegbuzie, 2007). At the end of every filmmaking workshop session, the researcher (MG) wrote reflective summaries of her observations. Observations included descriptions of student discussions, comments and student engagement (Fredricks, et al., 2011) as demonstrated by animated discussions and emotional disposition e.g.
laughter. Interviews were conducted with all student participants (n = 36), the two teachers and one coordinator (Table 4.1). The intention was to interview audience members at the community screening but this was not pursued as the author who facilitated the workshops was also involved in technical aspects of the community screening and therefore had no time to interview audience members.

Due to the order in which the filming workshops were conducted and logistical constraints not all schools groups had the opportunity to view films made by other school groups. School Rainbow is the only school that saw films from the other school groups during their community screening. The day after School Nyasa’s community screening, select films from School Quandong were shown. Students at School Quandong did not view any films made by other school groups.

Interviews with students focused on the process and experience during filmmaking and viewing theirs and other films, the selection of topic and science and cultural experiences at school and at home. During the interview a think-aloud protocol was conducted (Davey, 1983). Whilst student films were playing, students verbalized the thought process and rationale of their audio and visual content of their film. Think-aloud protocol is a valid method for researching cognitive processes (Davey, 1983). It is a way to understand the subjects’ development of thought. It gathers qualitative information on students’ retrospective intentions and reasoning behind choices of particular images, music, and stories (Schul, 2010).

Interviews with teachers and coordinators were conducted after the conclusion of each workshop and focused on their expected and perceived final outcomes of the program. Questions were also asked about the method of science instruction at school, their opinions about cultural diversity and culturally responsive teaching at the school.

4.4.4 Data analysis

Interviews and think-alouds were transcribed and coded to explore themes that related to the effect of filmmaking and connecting science and culture. Thematic analysis interprets research data by identifying, analysing and recognising patterns (themes) within data (Braun & Clarke, 2006, p. 79). Data familiarization and immersion began during the transcription phase followed by repeated reading of the transcripts (Braun & Clarke, 2006). Data driven open coding searched for semantic, surface level themes in
participant responses and observations (Boyatzis, 1998). Full attention was given to all transcripts with systematic analysis searching for as many codes as possible. Referring themes back to research questions refined theme descriptions; for example scientific representation in films was clarified to describe specific reference to science in films using either audio or visual modes, with science content signified by terminology, equipment, processes or explanation. Validity of themes was checked against the entire data set to verify meaningful interpretation of the data, to find any data that were missed in previous phases and to assess whether themes related to the research questions.

Aboriginal culture was a large theme with a number of codes: language, pride, shame, connection to country, family and privilege. These codes revealed important aspects of student identity and are discussed in detail in the next chapter because the significance of the findings on student’s cultural identity required additional theoretical framing. This chapter focuses on whether participation in the process of filmmaking supported students’ bridging home and school worlds.

Analysis revealed eleven broad themes (Figure 4.1). These were allocated into five categories which are used to describe the filmmaking process: film topics, science content, culture content, engagement and technical. Themes overlapped into more than one category. For example the themes science at home, science at school, and scientific representations were allocated to the categories: science content and film topics. Categories were then correlated to Moje et al.’s (2004) funds of knowledge - peer, family, community and popular culture. Not all codes within the themes related to Moje et al.’s (2004) four funds of knowledge. For example the code of creative expression in the theme engagement did not correlate with any of Moje et al’s (2004) funds of knowledge. Thus we added personal and school as funds of knowledge. Family and community were combined as they closely relate. For example connection to country related to both family and community. Within each school, we related the different funds of knowledge to the five categories. Patterns were revealed in comparing the instances in which types of funds of knowledge were called on in different contexts across the school groups.

The interviewer and workshop facilitator was the same person; that was advantageous as there was already a rapport between interviewer and respondents. However a potential disadvantage was that respondents (teachers and students) could be biased,
offering socially desirable responses. Therefore triangulation was important to verify interview responses (Creswell, 2008; Orne, 1962; Rosenthal, 1976). Classroom observations and film analysis provided further elaboration and triangulation of themes (Flick, 2007).

A growing number of research methodologies exist for studying video. Multimodal meaning making, based on social semiotic traditions, extends beyond using language to create meaning. It encompasses other communication modes such as gesture, gaze, sound, colour, and language in print and digital media (Kress, 2009; van Leeuwen, 2005). A majority of studies that use multimodal analysis of video in the educational context tend to apply it to video that has been generated by filming students and or teacher interaction in a classroom environment or informal setting (Rostvall & West, 2008). Although we were interested in how students assign meaning to the connection between their home and school worlds, we studied this by examining what and how students employed funds of knowledge in their video. Rather than looking at semiotic encoded signs or meaning, we categorised the subject matter students chose to film for example music or food. The film topics were counted with some films having more than one topic, for example music and dance. Content analysis was undertaken to determine how science and culture were represented. For example – was cultural or scientific language used? What images of science or cultural were shown, for example specific objects like beakers, test tubes, musical instruments?

We describe the analyses of films and contexts in relations to funds of knowledge supported by quotes and observations to elucidate whether student-generated films about science and culture bridge home and school worlds and the types and effects of funds of knowledge students draw on.

4.1 Findings

Each of the five categories (Figure 4.1) is discussed in relation to the five funds of knowledge used by students in their filmmaking. Filmmaking about science and culture incorporated a range of funds of knowledge that were invoked in different contexts (Figures 4.2). Figure 4.2 describes the categories or contexts in which different funds of knowledge were called on according to school group.
### Code vs. Theme

<table>
<thead>
<tr>
<th>Code</th>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>pride, shame, language, connection to country, privilege, family</td>
<td>Aboriginal culture – refers to Aboriginal culture</td>
</tr>
<tr>
<td>parents, books, movies, observations, asking questions</td>
<td>Science at home – refers to knowledge gained and activities conducted at home</td>
</tr>
<tr>
<td>lab experiments, scientific language, group work, investigations, teachers, equipment</td>
<td>Science at school – refers to knowledge gained and activities conducted at school</td>
</tr>
<tr>
<td>dance, music, clothing, family, language, housing, food, drums, hunting</td>
<td>Cultural representations – refers to audio or visual depictions of culture</td>
</tr>
<tr>
<td>experiments, forces, chemistry, chemical formulas, gravity, chemistry, adaptations, environment</td>
<td>Scientific representations - refers to audio or visual depictions of science</td>
</tr>
<tr>
<td>Not enough time, editing, teamwork</td>
<td>Challenges – refers to expressed or observed difficulties</td>
</tr>
<tr>
<td>audience, cameras, friends, outside family, watching back, editing, adding music and titles, recording friends and family, taking cameras home, acting, community screening, applause, certificate, creative expression</td>
<td>Engagement – refers to instances or conditions which lead to active involvement</td>
</tr>
<tr>
<td>communication, topic choice, research, acting, filming, editing, computer skills</td>
<td>Teamwork – refers to instances where individuals worked together</td>
</tr>
<tr>
<td>dance, music, food, hunting, sports, games, plants and animals, environment, Aboriginal culture</td>
<td>Films topics – refers to topics chosen</td>
</tr>
<tr>
<td>forces, food, cooking, dancing, music, energy, weapons</td>
<td>Science and culture connections – refers to examples of science and culture connections</td>
</tr>
<tr>
<td>tolerance, understanding, interest in others, racism</td>
<td>Intercultural understanding – refers to characteristics of intercultural understanding</td>
</tr>
</tbody>
</table>

### Categories

#### Funds of knowledge

<table>
<thead>
<tr>
<th>Sources of knowledge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peer</td>
</tr>
<tr>
<td>Family &amp; community</td>
</tr>
<tr>
<td>School</td>
</tr>
<tr>
<td>Popular culture</td>
</tr>
<tr>
<td>Personal</td>
</tr>
</tbody>
</table>

#### Categories

- **Films topics**
  - nature of the topic students choose for their film, includes themes – Aboriginal culture, cultural and scientific representations

- **Science content**
  - descriptions of science, includes themes – cultural representations, science at home, science at school

- **Culture content**
  - descriptions of culture, includes themes cultural representations, science and culture connections

- **Engagement**
  - active involvement, includes themes engagement and teamwork

- **Technical**
  - student use of hardware and software, includes themes challenges, teamwork

---

*Figure 4-1 Development of thematic analysis from codes to categories.*
We caution that Figure 4.2 does not represent frequency; the number of instances of a theme is not reported because our research explores whether students drew on funds of knowledge not the quantitative extent to which they drew on funds of knowledge. For example popular culture and film topics for School Rainbow can refer to a single instance or multiple instances of students citing popular culture in relation to film topics.

We explore the funds of knowledge invoked within each different category or context (film topic, science content, culture content, engagement and technical). This is in contrast to other studies (Calabrese Barton & Tan, 2009; Moje, et al., 2004) where funds of knowledge have been the principal classification and contexts the sub-classification. We have reversed the relationship in order to describe the contexts that supported the incorporation of funds of knowledge. We note and embrace that funds of knowledge can overlap. For example references to teaching Aboriginal scientific knowledge at school relates to both school and family and community funds of knowledge.

4.1.1 Film topics

The topics chosen by the 69 students for their films were diverse (Tables 4.1 and 4.2). Film topics drew on all funds of knowledge: personal, peer, family and community, popular culture and school (Figures 4.2, 4.3 and 4.4). Film topics that were common to all schools were games, sport, music and food. Films about games, sport, music and dance drew on popular culture funds of knowledge whilst films about food made use of family and community funds of knowledge. Films in which students displayed talents or interests drew on personal and peer funds of knowledge. In deciding the topic of their film, students sought classmates’ opinions, drawing on peer funds of knowledge.

**Personal funds of knowledge**

When students were asked why they chose their topic, most responded by saying that it was a topic or hobby they liked and or were familiar with, having learnt it either at home or school. For example students in the Malawian school, Nyasa, often stated “It was easy for me to do this topic.” Personal funds of knowledge also related to family funds of knowledge when students had access to resources at home; one student made a film about adaptation because she had pet ducks. In her movie, she was able to visually demonstrate ducks’ webbed feet and waterproof feathers.
Figure 4-2 Categories/contexts of aspects of filmmaking that invoked funds of knowledge in three schools (a. School Rainbow, b. School Quandong, c. School Nyasa).
Shading refers to at least one instance when a particular context invoked a fund of knowledge.
**Table 4-2**

*Film topics by school. (n= total number of films in each school. Some films incorporated more than one topic hence the number of topics exceeds the number of films).*

<table>
<thead>
<tr>
<th>Topic</th>
<th>School Rainbow (Metropolitan, Western Australia) (n = 8)</th>
<th>School Quandong (Aboriginal regional, Western Australia) (n = 11)</th>
<th>School Nyasa (Malawi) (n = 18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aboriginal culture</td>
<td>1</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Dance</td>
<td>0</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Environment</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Experiments</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Family</td>
<td>1</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Food</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Games and sports</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Music</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Other*</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Plants and Animals</td>
<td>0</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

*Other: School Rainbow – Batman, Fireworks, School Quandong – Interviewed students in the Follow the Dream program.

**Peer funds of knowledge**

Peer funds of knowledge guided choice of film topics. For example students wanted to know what films their peers were making and whether other students would like their film. Students often wanted to make films that were interesting to and different from their peers. A student who made a film about Kung Fu said

*There was a lot of good ideas like basketball and Batman so I don’t know so we just chose a fighting style.* PI, School Rainbow

One student at School Nyasa expressed concern about what his classmates would think of his film.

*What if people don’t like my film? All these things started running through my mind like way before they even started watching the film. What if they don’t think it’s nice. What if this? What if that? Then when my friends started showing me their films [during editing in class] I felt like mine was wack [bad]. Mine was different from the others.* MO, School Nyasa

At School Rainbow, groups of three students had to agree on a topic. The groups chose topics that they were familiar with and interested them (e.g. music, basketball). A group
of three boys (two Australian and one Malaysian) at School Rainbow produced a film about Malaysian spinning tops because two members in the group had spinning tops. A group of girls at School Rainbow chose coffee because they could relate it to all their cultures (Ethiopian, Australian and Libyan).

**Family and community funds of knowledge**

Film topics at School Quandong, the Aboriginal after school homework program, were mainly drawn from family and community funds of knowledge (e.g. going hunting for mardu - goanna, Australian monitor lizard - and interviewing grandmother).

An Aboriginal student who made a film about hunting for goanna wanted to show how Aboriginal people catch their food.

> Because other people can learn a lot, learn about what my dad does. Show people how we catch our food. HC, School Quandong

Many students at School Nyasa chose to make films raising awareness about issues to do with the environment (e.g. water pollution and deforestation) drawing on community funds of knowledge. One student at School Nyasa made a film about science in cultural foods (nsima – a starch based staple food in Malawi), saying he wanted to “sensitise” people to the connections between science and culture.

> After I saw that many people they don’t think of science and food. They don’t promote science with food. They just think of eating. They don’t understand that when cooking there is some science involved. From what I have seen culture relies on science. We should sensitise people so that they know they are doing science so they teach other people. MT, School Nyasa

**Popular culture funds of knowledge**

Popular culture funds of knowledge in film topics were evidenced through films about trending sports like parkour (also known as free running which involves rapidly negotiating obstacles by running, jumping, and climbing), Brazilian capoeira (Brazilian martial art), hiphop dancing, as well as a film about Batman.
**School funds of knowledge**

Experiments was a film topic that was unique to School Nyasa (Figure 4.2c). Films about experiments included a comparison of the rate at which salt and sugar dissolve or why some objects float and others sink. School Nyasa also had films about plants and animals, which mostly related to adaptation for example how and why flowers attract bees.

### 4.1.2 Science content

Science content refers to either audio and or visual representation of scientific processes (physical, chemical or biological), explanations or use of terminology or equipment. The presence and level of scientific detail varied in the films and mainly drew from personal, peer, (to a limited extent) school and family and community funds of knowledge. There was only one instance of popular culture funds of knowledge related to science content at School Rainbow (Figure 4.2a). The science content ranged from none at all to films about experiments (Figures 4.2b and c). For example the videos on dancing both at School Quandong and School Nyasa made no reference to science while some of the films made at School Nyasa explicitly incorporated experiments. Science content was mostly accurate, with no misconceptions presented. In relation to what made science enjoyable, students mentioned the following: working in groups, having a good teacher, doing experiments, blowing things up, doing experiments that go wrong and doing interesting investigation like forensic science. Students disliked writing reports and using big scientific words.

> Sometimes I enjoy it [science] but sometimes like when we have to do a report on it or like using all these big words - that’s what I find hardest.

PN, School Rainbow

**Personal funds of knowledge**

Some films had scientific explanations, for example the chemistry involved in making fireworks, gravity in bouncing basketballs, physical forces and friction and physics in spinning tops. These films were made by individual students or groups of students who either excelled in science class or students who were motivated to research the topic. At School Rainbow, the Malaysian spinning tops film discussed the gyroscopic effect and
the fireworks film presented the chemical composition of fireworks. Both these groups had students who were in Primary Extension and Academic Challenge, a West Australian government program for gifted and talented students.

There was variation in students connecting science to their everyday lives. School Quandong had no films that made explicit reference to science hence the absence of science contexts in Figure 4.2b. The students at School Quandong had a limited understanding of connections between science and culture (also discussed in Chapter 2).

*Culture, hiphop is from like, most people do it. They get to learn it and different cultures learn hiphop. Science in it, I am not sure.* FS, School Quandong

Students at School Nyasa who made videos about dancing, although they did not reference science in their films, when asked how dancing related to science were able to perceive connections.

*In dance, there is science in movement of joints and the energy used when dancing.* ME, School Nyasa

Students at School Rainbow expressed difficulty in researching the science connections. A student who made a film about “pap” (a starch based staple food in southern and eastern Africa) had difficulties finding information.

*Well it took us a long time cause I did not really know what it was, but we put it on the internet and nothing really came up about it because nobody really knows what pap is and stuff like that so it was pretty hard trying to find information about the science of it.* PR, School Rainbow

There were also problems with articulating the science as expressed by a student who made a film about African drumming.

*I think also what was difficult was trying to word what we were trying to say like the science. It was hard to talk about the science in African drumming.* PN, School Rainbow
Peer cultural funds of knowledge
School Rainbow was the only school where students were observed during class searching for scientific information on the internet. Most information that students retrieved for example on how gravity acts on basketballs or the gyroscopic effect of spinning tops were taken from Wikipedia.

Well basically me and PO spent the most time on the computer because PE and PJ kind of don’t do the computer stuff so we decided we’ll just do that, the time that we go on the computer we will research. PK, School Rainbow

When asked the sites she used PK said, “I had a search on Wikipedia and Wikianswers.”

Family and community funds of knowledge
Rarely was the role that family played in stimulating interest in science mentioned by students. One student at School Rainbow mentioned his parents encouraging his interest in science.

My mom and dad like the idea of me liking science so they buy books like science books and such for me to read and my father is a networking manager worked in Intel and my mom is doing her PhD on poverty. PL, School Rainbow

This student also commented about observing things at home and asking about it in class, for example how does rice change from “grainy” to “fluffy” when it is cooked. This is the same student whose group made a film about Malaysian spinning tops and gyroscopic effects.

In contrast, other students at School Quandong and Rainbow reported they could not do science at home because this required special equipment.

Cause I would need the tools from school to be able to do at home. HT, School Quandong

I mean I cook but I don’t know if that’s really science but not really. PR, School Rainbow
**Popular culture funds of knowledge**

Only one group attempted to explicitly combine science and popular culture, a group at School Rainbow that made a film about Batman. The film portrayed Batman catching a robber using a *batarang*, a bat-shaped throwing weapon.

*We all liked Batman and we thought there is a lot of science in his weapons.*

BTN, School Rainbow

Films about dance at School Nyasa and School Quandong, although based on popular culture, did not make any explicit references to science.

**School funds of knowledge**

The importance of teachers was highlighted in interviews of students. School Quandong students expressed interest in and acknowledged the importance of science but had experienced problems with science teachers.

*Well at this school we don’t have a very good [science] teacher. So like yeah I’m thinking I don’t really like it [science] as much.* PN, School Quandong

*Because well, I just like doing the experiments and I learn how things work. I don’t like it because we don’t get taught hardly anything because everyone just talks in class.* HC, School Quandong

At School Rainbow students commented that they had not been learning much science.

*Well the room back there is a science lab but we don’t really use it much but the Year 3s , I think, they use it lot cause their teacher is like very into science and she just gets the kids into science by doing experiments and what not.* PL, School Rainbow

School Nyasa students drew on school funds of knowledge for the science content of their films. For example two films from School Nyasa in Malawi featured experiments. In one, a student recruited and filmed two of the best science students in the school conducting an experiment in the science laboratory investigating which dissolves faster in water, salt or sugar. In another film, a student discussed Sir Isaac Newton and
demonstrated forces followed by an experiment in which she placed different items of stationery (pencil, eraser, ruler) in a bowl of water to see which ones sank or floated.

Ms. England, a young British science teaching graduate, was mentioned several times by students at School Nyasa. She had left the school at the end of the previous term. Students commented that she taught with a lot of everyday examples and took them outside of the classroom for some of their science lessons.

Didactic teaching was the main teaching style observed in the new science teacher’s class. Mr. Nyirenda, a Malawian with eight years science teaching, was also the deputy headmaster. He rigidly stuck to the Cambridge Key Stage 3 textbooks and often used call and response as a teaching strategy. School Nyasa follows the International General Certificate of Secondary Education (IGCSE) curriculum. Mr. Nyirenda commented that in his science classroom he did not attempt to adapt the curriculum to a local context, rationalizing that local examples would not be relevant for students sitting international exams. Culture or indigenous knowledge was not taught or integrated into the school. Mr. Nyirenda was also the National Science Fair coordinator. The Malawian National Science Fair had been running for a few years as a showcase of scientific talents of students from a number of private and government schools. He was aware of local cultural examples of science through his involvement in the National Science Fair. For example at one of the science fairs, a government school had an experiment using “chidulo”, ash or bicarbonate of soda in an acid-base reaction. He observed that not providing local examples in the science class at School Nyasa did not affect student performance as the Year 9s performed better than average. He further commented that the students were extremely competitive, especially those coming from disadvantaged backgrounds as a number of students in that class were orphans and vulnerable children who had received meritorious scholarships to attend School Nyasa.

Aboriginal students at School Quandong recognised science as important. One student noted the opportunity to teach Aboriginal scientific knowledge as a vehicle to portray Aboriginal people as intelligent.

*You know how people say that Aboriginals are dumb when they are not. That could teach us that we are smart in many kinds of ways and get to know about our history back in the day and Aboriginals also get to learn*
more cause sometimes maybe some of their grandparents did not tell them or anything. HR, School Quandong

4.1.3 Culture content

Dance, music, food, games and sport were the common representations of culture that drew on all funds of knowledge. School funds of knowledge were rarely used in relation to culture (Figure 4.2).

**Personal funds of knowledge**

Personal funds of knowledge within the culture context related quite strongly to family and community funds of knowledge. An Aboriginal student at School Rainbow interviewed her grandfather for a film about Aboriginal history and the Stolen Generation.

> When me and PY and PK heard the stories about how Aboriginals used to get treated back in the olden days, I didn’t think it was fair so I wanted to send a message out to people and tell them that it was not right for people to be treated like that and give them a better understanding of why you shouldn’t be racist [hesitates] and why there shouldn’t be racism. PS, School Rainbow

An Anglo-Saxon Australian student at School Rainbow who recently moved to Perth from a remote farming community, commented on cultural difference not being important.

> I don’t think it really matters whether you are from a different culture or not. You just fit in, go along with it and have a good time really. So I don’t think it [culture] really matters. PH, School Rainbow

**Peer funds of knowledge**

Students drew on peers for cultural content by having them act in their videos. A student who made a film about the Follow the Dream program interviewed her peers. Students at School Nyasa for their videos created synchronized dance routines with their peers or dance solos. At School Rainbow, a student asked a peer from another
group, who had knowledge of how to make pap (starch based African staple food) to help her team make pap for their group’s film.

**Family and community funds of knowledge**

Family and community funds of knowledge were key sources for Aboriginal students both at School Quandong and School Rainbow. Aboriginal students were keen to interview their family and share historical or personal accounts of their family members.

*The film I made was about my Grandmother and I interviewed her so people who watch the video could know about [area] and what it was like back in her days. She’s been here a long time and she would know more knowledge than us. She would tell us a bit about the history and her culture and all that.* HE, School Quandong

An Indian student at School Nyasa which predominantly has Malawian students commented that culture should not be taught at school.

*We learn culture at home. Our parents teach us. We don’t have to learn it at school.* MD, School Nyasa

Culture content in relation to family and community funds of knowledge was also exhibited in films about food. For her film about the Ethiopian coffee ceremony, a student had her mother behind the camera directing her. Two Malawian students both filmed their mothers cooking nsima (a starch based African staple food). A similar film about the same food, called “pap” in South Africa, was made by a group with a South African student at School Rainbow. Together with an Ethiopian student from another group, the five girls prepared pap in the home economics kitchen at school. The Australian students in this group ate pap for the first time.

Following both the story box activity (Chapter 3) and filming, students were more likely to demonstrate connections between science and culture compared to results from the group meaning map activity (Chapter 2). An Aboriginal student at School Rainbow mentioned how the materials that Aboriginal people painted with were connected to science and that a number of practices had scientific explanations.
Culture and science was part of Aboriginal life. There was all different Aboriginals, Noongars, different names and they had a cultural background. They used material to make their houses and things to drink and eat and so basically it was part of science without thinking about it. PS, School Rainbow

Some students at School Quandong saw the importance of both science and culture but considered they should be taught as separate subjects.

Aboriginal knowledge as one subject. Because you probably learn a lot of stuff from Aboriginal historical knowledge. They used to do interesting stuff back then, like...they used to find tracks of animals like mardu [goanna], kangaroos, birds, turkeys, emus like all them. And they used to make hell good boomerangs like the number seven. Light but nice and accurate and deadly. And how they carved is pretty good because of the shape of it, which makes it go longer, more distance plus easy to throw and kill. HD, School Quandong

**Popular culture funds of knowledge**

Dance in particular drew on popular culture funds of knowledge and was portrayed in contemporary dances, hiphop and RnB films at both School Quandong and School Nyasa. An Aboriginal student commented he preferred to make a film about contemporary dance than traditional dance. A Malawian dance video, Girls Splash had two girl presenters dressed in similar attire - pink and black hoodies and dungarees, walking with swagger, using hand gestures and language like “keep on rockin” resembling a black American hiphop video. Another dance video at School Nyasa had reference to Michael Jackson and had a boy doing the moonwalk. During the community screening at School Nyasa, there were more applause and audience murmurs for dance films than most other films. Popular culture funds of knowledge were also invoked in the choice of music for their films. Most students reported they chose songs that had been or were a current hit. Groups from School Nyasa and School Quandong independently chose the same song.

An interesting example of a combination of culture and popular culture was the film about Batman. The batarang, a bat-shaped weapon, is derived from boomerangs.
School funds of knowledge

Students from School Nyasa elaborated on a number of examples of how science and culture were connected. In this instance, we place this in school funds of knowledge because of the role that their previous teacher Ms. England had in teaching science in relation to everyday life.

Science and culture is related because in culture they are things that are involved in science like to build a house that involves science so a thatched house does not leak, to make it strong. To make a drum, to change the sound, to keep a hole underneath the drum, to heat the top of the drum so it makes a better sound; that involves science. MT, School Nyasa

The science knowledge and culture knowledge – they are the same but different. They are common things that unite them. Say for example when a person is cooking, there is a reaction taking place that is the way people live. So it is cultural but there is science in it. MW, School Nyasa

Science is our everyday thing. We breathe, we talk about respiration in class. We eat, we talk about chemical energy. We move, we talk about kinetic energy. We cook that’s also like kinetic energy – heat. Chemical energy when we eat the food. We can’t always see what is happening. That is why we have to do experiments. ML, School Nyasa

Not all students at School Nyasa agreed with connecting science and culture. A student who made a film about the water cycle saw science and culture as two distinct aspects with science being more important.

It does not make sense to join tradition and science. As in dancing, traditional. Science is the way you communicate. There is no communication in dancing. MR, School Nyasa

She felt none of the films that students at her school (School Nyasa) combined science and culture.
In science there is a lot of things happening, you think for communication you use science, you have to think how can I communicate this. But in tradition it does not need critical thinking. MR, School Nyasa

Ms. Carr, the Follow the Dream coordinator, commented that at School Quandong there were limited opportunities for sharing Aboriginal knowledge or information about other cultures. Through her involvement in coordinating the Staff Association, Ms. Carr said she had introduced a segment in their regular meetings where teachers from different departments talk about their teaching. In one of the meeting the Social Studies Department encouraged more cross-curricular teaching; for example the music department, home economics and history department could all focus on a particular culture e.g. Asian.

4.1.4 Engagement

Students demonstrated engagement or active involvement when invoking all funds of knowledge although less so for school funds of knowledge. Engagement was indicated by enthusiasm (e.g. students working on their films during lunch and tea breaks), interest (e.g. students taking notes), emotional reactions (e.g. laughing or crying). The levels of engagement varied at the different schools, School Nyasa students were extremely keen. On her return, one student who had been at home sick, insisted on making her film even with only a few days left. In contrast, students at School Quandong had to be found, brought in and supervised during tea breaks to film or edit their movies. A reluctant student at School Quandong produced a film because the coordinator persisted. The student did not have a topic; Ms Carr arranged an interview with the school’s Aboriginal and Torres Strait Islander Education Officer, wrote the questions for the interview and during break went looking for the student to film the interview.

Personal funds of knowledge

The program achieved a sense of empowerment and confidence as commented by the coordinator at School Quandong.

I think their own confidence built up. Seeing what they could do. And the way they all helped each other. Just part of that process when they can see
that they can actually help someone else. That was good for them as a group. Ms. Carr, School Quandong

What I have specifically learnt and what is important to me... when making a film you have to be steady. You have to be ready. You shouldn’t be afraid. Just feel as normal and be as comfortable as you can. MA, School Nyasa

One of the students at School Rainbow was touched and said he was “sad” when he watched his fellow students film about Stolen Generation and Aboriginal history. He had no prior knowledge that “Aboriginals had no rights for 45 years.”

There is a lot of stuff going on that we did not know that happened a long time ago. Aboriginals getting taken away. Malawi students, how like they don’t have as good as houses and just stuff like that. PI, School Rainbow

A number of aspects were mentioned that contributed to the engagement and enjoyment of students in the project. The novelty of making films as part of a science class was particularly exciting for the Malawian students and is an example of an aspect that fits into two categories (engagement and technical). The opportunity to make films in any Malawian school is a rare and unique opportunity for students. Students at School Nyasa often commented that “holding the camera” was a lot of fun.

When you are filming, when you hold the camera, you start to think what if this never happened. You start to think that this is an incredible opportunity...Truly speaking this is a once in lifetime chance. I don’t think a chance like this will ever come again. The filming was incredible. Holding the camera was one of the best things that I really liked. After the film was finished, the sound of people clapping at my film made me feel so happy. All my hard work had paid off. MO, School Nyasa

..for them when they heard that they would be making films, it was something that perhaps they never thought of doing in their lives so that brought some excitement in them. It cultivated an interest in them that they were doing something new. It is probably the best approach. Mr. Nyirenda, School Nyasa
Students’ engagement is also illustrated by some students being willing to continue with their tasks outside of set times. At School Rainbow and School Nyasa, some students took control of their learning, even continuing with their editing or filming during recess, lunchtime or after school.

*We really enjoyed it cause it was something new. Something nice. It was the first time. We did not want to stop.* MA, School Nyasa

**Peer funds of knowledge**

Students enjoyed filmmaking because they could work outside with their friends during lesson time. For example an activity during the filmmaking workshop asked students to go outside and film different shot types.

*Everything was really fun cause we got to be out with our friends and stuff.*
PB, School Rainbow

*The most enjoyable thing I found was the whole thing and the fact it’s free and we get to spend time with friends. You go outside, we do filming and editing together, taking the sounds so that’s really good fun.* PL, School Rainbow

Ms. Peacock from School Rainbow commented that “developing (writing) their own stories and seeing the final product and working in teams” were the things she felt students enjoyed the most. She said that ICT skills, team work, creativity and own expression were the most valuable aspects for her students.

Teams at School Rainbow did experience friction. For example in one team, a student filmed and edited on her own. However for most teams, disputes amongst teammates were settled amicably.

*There was a few moments that I just thought, oh my gosh I can’t do this no more. I am backing out! Then with my teammates they really helped me and now it wasn’t really that bad. Working together especially with PBe because she wanted things her way and you know it’s hard to work with someone who just wants their way. To actually get the girls to understand what is pap and stuff like that cause they did not really understand it. Just*
like making the film by itself it was hard but it was a good experience. PR, School Rainbow

**Engagement: Family and community funds of knowledge**

Allowing students to take the cameras home enabled them to make films with or about their families. A student talked about interviewing her grandfather about the Stolen Generation and Aboriginal history.

> He sort of gave me a weird look cause he did not quite understand what I was talking about but then I explained more of what we were doing and he agreed to it and rang up his sisters cause they knew a lot and his Aunties and found out information from them and put it all together to make the film. PS, School Rainbow

This student later commented that through this film she was able to learn more about her family.

> I have learnt more about the people in our classroom. More about Aboriginal culture that I did not know. More about my background, my grandfather’s background. I did not know anything that he said in the film so I found that out. PS, School Rainbow

A student who interviewed her grandmother had fun with her sisters as they filmed their grandmother.

> I enjoyed video recording my Nana cause we did have a few laughs. HE, School Quandong

Another student made a film about family roles and interviewed her siblings and father.

> They got a bit embarrassed because some of them are camera shy. But after a few reps of doing the filming they actually had a laugh cause they thought it was pretty funny. PT, School Quandong

All students expressed an interest to learn about cultures.

> It would be actually nice to have something like that Aboriginal people or someone else like the Indigenous, maybe the Asians have something. Maybe
we need culture. Because primary school had a sea of cultures. The logo at the primary school, we learnt about France and Indigenous, Indonesians and Chinese. It was actually kinda fascinating to learn about other people’s cultures. It was really nice. I would like to know how other people think the world was created. HR, School Quandong

Sometimes for me its better to know more than just one religion and culture because then you can understand more about others and then if you meet some other, some people who are different, you will have an understanding of how they are and their culture. PN, School Rainbow

Ms. Carr had hoped more students from her program would have made films about their family. During the film screening at School Quandong, a father who watched his daughter’s video on Family Roles cried.

I liked the fact that it was a digital storytelling about their lives. That worked. The kids had not done that before and that I think was the success. We had HE who interviewed her grandmother and she spoke about skin groups and HC’s dad took her out hunting and showed her how to make damper and a set a trap. And that is why I liked it cause we started to get a record of their own families so they could be proud of it. And then we showed the results of these kids’ work. We showed it at the school and we had a party and parents rocked up to see it. And one grown man cried when he saw his daughter’s work. It was very emotional. So it was really good. I really liked it. Those that got really involved in it had really good stories to tell. The others just wanted the opportunity to just film and not attach stories to it. The ones that attached their story about their families, I found very beneficial. Ms. Carr, School Quandong

**Popular culture funds of knowledge**

Students spent a lot of time downloading and listening to songs in order to find a hit song that complemented their film. Students would bring songs on USBs and phones going through various permutations to get the soundtrack right for the beginning and end of their films.
**School funds of knowledge**

Mr. Nyirenda at School Nyasa felt that connecting science and culture through filmmaking gave students a fun experience of applying what they learnt at school at home.

> The assignments that we give students mainly are based on what they have learnt in class. The filmmaking exercise was an outdoor activity. The approach was actually different to the way I would do it in a classroom. I feel that there is actually a big difference. They were doing an outdoor activity. It was like fieldwork. That approach may have actually motivated the students, stimulated the learning environment. In short I would say the filmmaking project was a good project in the sense that students were able to go out to the communities and produce or make films and connect to what they learn in the classroom. I think it was a very good approach to making the students understand science is applicable in their homes, in their communities. Mr. Nyirenda, School Nyasa

He further commented that the filmmaking project was beneficial to students and should be done in other schools in Malawi.

> Filmmaking links science to culture. It can help demystify science and bring some excitement to learning and in that way students will like it. So I think in future, it is important to visit other schools, to do the same exercise. Mr. Nyirenda, School Nyasa

**4.1.5 Technical**

**Personal funds of knowledge**

During both filming and editing, decisions were made to ensure a good film. For example one group chose a particular shot to start with because it was the best parkour trick they could do. Most students, particularly in Malawi, reported challenges with editing. Students who did interviews not only found editing challenging but felt the three minute maximum length for the film was too short, unfair and difficult to put across the information they wanted to convey. Ms. Carr, coordinator at School Quandong, said if the project was to run again she would have it scheduled across the entire term, giving students plenty of time to take their cameras home, film and edit.
Students reported that directing actors (who were often fellow pupils) required them to manage difficult behaviour. Students also acknowledged the logistical demands of planning a film. During the interviews all students were asked if there was anything they would like to change in their film. Students at School Nyasa mentioned a number of things like audio, more visuals, props, extend the length. This contrasted to interviews at School Quandong where most students reported they were happy with their film and did not want to make any changes.

Peer funds of knowledge
Students acknowledged and capitalized on the strengths of each other. For example groups would either assign a student to do research or editing if they were better at the computer; would ask other students to exhibit their talent e.g. dancing; or invite a peer to narrate if they had good reading skills and clear diction. The group that made a film about basketball divided roles according to the basketball skills of the group members.

\[DP\text{ was our best shooter so we wanted him to take the shots and NP is a pretty fancy passing guy so we knew what we \textit{were} gonna do. And me and HPe just took turns with the camera works so I filmed this. And I actually tried dribbling in this clip but then I think DP’s technique of bouncing the ball is much better than mine.}\]

PA, School Rainbow

No other funds of knowledge were invoked by students in relation to the technical aspects of filmmaking.

4.2 Discussion
This research contributes to the body of evidence about funds of knowledge. Firstly, the process of filmmaking enabled students to draw on multiple funds of knowledge (personal, peer, family and community, school and popular culture). Secondly, filmmaking supported students’ exploration of science in their everyday lives and promoted intercultural understanding. Thirdly, filmmaking as a tool for incorporating funds of knowledge engaged and empowered students by giving voice to and legitimizing their personal, peer, family and community knowledge and experiences in a school setting.
In addition to further demonstrating the widely recognised benefits of students as filmmakers, students in this study found filmmaking about science and culture an engaging, empowering and enjoyable learning experience. It provided them an opportunity to acquire and practice technical skills, to work in a team, to research and explore the connections between scientific knowledge and cultural practices, to document and share personal stories, to experience and learn about their own and other cultures from their family and peers. Our findings of the impact of filmmaking about technical and communication skills, reasoning, engagement, enthusiasm, teamwork and affective domains (self esteem, confidence and empowerment) were similar to other studies in which students generated films (Kearney & Schuck, 2006; M. Reid, et al., 2002).

4.2.1 Funds of knowledge

During the filmmaking process, students drew mainly from personal, peer, family and community funds of knowledge (see Figure 4.2). Peer funds of knowledge were a significant source of both inspiration and anxiety for students. Students cared about what other students thought of their films. Moje et al (2004) described how peer funds of knowledge help students know how to “do” school. In our study this was demonstrated by the value students placed on classmates’ opinions and that they recruited talented students for their films. Peer funds of knowledge were also invoked when students worked together. Working outside with friends was an important and enjoyable feature of the filmmaking program that was noted by both students and teachers.

Popular culture funds of knowledge were recruited when students were deciding film topics and culture content of their films, especially in relation to using hit music as soundtracks or contemporary dance such as hiphop. Popular culture funds of knowledge, although prevalent in our studies, were not the dominant fund of knowledge as was found in Moje, et. al (2004) study. Popular culture was highly valued by students in this study but not to the same extent as Moje et al’s (2004) finding that youth drew on popular cultural funds of knowledge more than any other funds of knowledge. In our study, popular culture was important for students’ street credibility but that related to how peers saw them. This is consistent with Barton & Tan (2009) and Moje’s et al (2004) observations that students are strategic in their use of funds of knowledge. In our
study, students mediated peer and popular culture funds of knowledge for example by asking a talented friend to dance to a popular hit song or showing off a talent - parkour, back flips, basketball. Aboriginal students invoked peer funds of knowledge, family and community and popular culture funds of knowledge. Family and community funds of knowledge were recruited in all schools by groups in which students filmed their mothers cooking or interviewed a member of their family.

School funds of knowledge were rarely recruited at School Quandong and School Rainbow. Family and community funds of knowledge were the preferred funds of knowledge for Aboriginal students at both School Rainbow and School Quandong. However, unlike School Quandong, the Aboriginal students at School Rainbow were able to draw on school funds of knowledge in a cultural context. This may be because School Rainbow had an Aboriginal and Torres Strait Islander Education Officer who conducted cultural activities such as cooking and painting with Aboriginal students once a week.

Games, sports, food and music were topics that were common to all schools. This finding is not surprising as our previous research found, across seven schools, food and music were amongst the top cited concepts that linked scientific knowledge and cultural knowledge (Chapter 2). A number of multicultural studies have used food as a subject to engage students in learning science and culture (Calabrese Barton & Tan, 2009; Tsurusaki, et al., 2013). Music has been used to engage and empower marginalized youth (Elmesky, 2005). In our study, the students approach to both dance and music favoured more contemporary styles - hiphop and RnB. These contemporary styles are related to students’ street credibility through peer and popular culture funds of knowledge (Moje et al, 2004).

The topics that students filmed were mainly material culture (Malaysian spinning tops, food) or skills and process (dancing, playing an instrument). The only film (The Dingo Man) that made reference to spirituality was a made-up Dreamtime story. In our previous studies, students reported religion connected science and culture (Chapter 2). The lack of films about religion and spirituality could be attributed to number of reasons: difficulty in locating specific examples of cultural values and beliefs that connect to science; cultural values and beliefs can be visually problematic to depict;
beliefs are sacred and cannot be shared publically; or films describing cultural values are not “cool enough for school”.

It is worth noting that Aboriginal students often spoke about not knowing their language and having limited knowledge of their cultural history. They often situated Aboriginal culture in the past and spoke of hunting as one of the few traditions they currently practiced. Aboriginal culture as old world knowledge has been a recurring theme in this research (see discussions in Chapters 2 and 3). The ways in which modern Aboriginal practices could be represented to respect and acknowledge the accumulated body of knowledge and ongoing evolution, warrants further research.

4.2.2 Connecting science and culture and intercultural understanding

Many studies have reported that students do not like science because it bears little resemblance to their personal experiences (Basu & Calabrese Barton, 2007; Elmesky, 2005; Goodrum, et al., 2011; Tytler, 2007; Zimmerman & Bell, 2012). This filmmaking project allowed students to choose their own topics. As mentioned before, our intention was for students to take maximum ownership of their projects. With that and the need to minimize bias in our data collection, very little guidance on topic choice was provided. Students were told connecting science and culture was open to their own interpretation. Students often chose topics that they were familiar with, had access to resources or were passionate about. In most cases (except for the films solely on science), students chose the cultural aspect first and then investigated science that related to that topic. This suggests that students were able to apply science in their culture or everyday life.

There was variation in the extent to which students made connections between science and culture. In the absence of culturally responsive teaching, students can fail to locate or see themselves within the scientific community (Calabrese Barton & Tan, 2010; Witz, 2000). Students at School Quandong rarely made science and culture connections in their films or in their group meaning maps (Chapter 2) in spite of having access to and using as rich resource of family and community funds of knowledge. The filmmaking activity at School Quandong was not situated in or during a science class but instead was part of an afterschool homework program. At School Nyasa and School Rainbow, where groups made more explicit science and culture connections, the researcher (MG) had negotiated with teachers to schedule time during science and
computer classes for students to work on their films. An exacerbating factor at School Quandong was the problem of science teacher transiency. Four science teachers had joined and left the school in one year. The Follow the Dream coordinator attributed the rapid teacher turnaround to teachers’ lack of willingness to live in a regional area, a factor that has been reported on in studies of teacher transience in regional and remote areas of Australia (Hudson & Hudson, 2008).

The role of teachers is important in teaching students about science in their daily life (Aikenhead, 2001; Calabrese Barton & Tan, 2009; Fitzgerald, Dawson, & Hackling, 2013; Tsurusaki, et al., 2013). Students at School Nyasa demonstrated an understanding of science in their lifeworlds (being in this world) (Kozoll & Osborne, 2004). In particular a student at School Nyasa made a film that had a number of everyday examples of forces in action. It appears that he used science as a lens to interpret his experiences. His participation is discussed further in the next chapter as demonstrating a scientific identity (for further elaboration, see Section 5.5.1, page 152). Ms. England, the previous science teacher at School Nyasa taught students using relevant examples whilst their current Malawian teacher stuck more rigidly to the British curriculum. Other studies have found Malawian teachers tend to have a negative attitude towards indigenous knowledge and often don’t know how to scientifically explain local knowledge (Glasson, et al., 2010; Phiri, 2008). Ms. England was a relatively new graduate of science teaching and had been recruited and moved to Malawi for the sole purpose of teaching science at School Nyasa. Her interest and motivation to teach science in Malawi apparently translated into enthusiasm for using locally relevant examples in her teaching. Contrastingly, students at School Quandong reported having teachers they did not like, conducting dull experiments (like watching ice melt), not having any practicals for an entire term and having a teacher being unable to manage student behaviour.

Another notable difference between students at School Nyasa and School Quandong was their competitive nature. Students at School Nyasa offered several comments when asked if they would like to make any changes to their film whilst students at School Quandong were content with what they had made even though there was room for improvement. This finding is discussed further in the next chapter which explores what this study reveals about identity.
This filmmaking activity was an independent inquiry as students chose and researched their own topics. School experiences where students conduct independent investigations have been found to engage and sustain student interest in science (Jones, Taylor, & Forrester, 2010). Jones et al. (2010) found that independent exploration of science was more important than hand-on activities or engaging content for sustaining students’ interest in science. This corroborates our own experiences with university students (Longnecker & Gondwe, in press).

Students reported that researching scientific knowledge was difficult. Students did demonstrate that they were able to retrieve music they needed from the internet. However internet research was only applied by a few students when it came to retrieving information on science. This finding is similar to Moje, et al’s (2004) findings were they observed the challenges students experienced searching for scientific information on the internet. Because we wanted to observe how, in what ways and to what effect students were making connections between science and culture, very little guidance was provided on how to research the connections. The students at School Nyasa had no trouble with describing the connections. However School Rainbow, Year 7 students reported a number of difficulties researching science and culture connections. The students at School Rainbow who were able to clearly articulate science and culture links were identified by their teacher as top achieving students or students involved in the Primary Extension and Challenge program or gifted and talented students. Moje, et al (2004) recommend beginning lessons by demonstrating to students how to conduct internet searches on science information that relate to students’ everyday lives.

School Rainbow provided an interesting case study because students had to work in groups. Groups had to reach consensus on a film topic. Student groups were mostly of mixed ancestry and students were able to learn and in some cases experience a fellow group member’s culture. For example in the group where a student made pap at school, other group members reported enjoying cooking and then tasting the pap. An Anglo-Australian student learnt about and described being saddened by how Aboriginal people were treated. Particularly at School Rainbow, students benefitted not only by way of connecting science and culture but also from increased intercultural understanding. Filmmaking welcomed all the different cultures in the classroom without appearing to privilege any. Furthermore filmmaking engaged students of all abilities including the gifted and talented students.
4.2.3 Engage and empower

Giving students authority to make films about a topic of their choice and allowing them to take the cameras home gave students voice and ownership. It validated and legitimized other funds of knowledge within the school environment. This echoes Upadhyay’s work (2009) in which students seeing families engage in science empowered students and created an awareness that science has a place at home. For those students whose films tended towards culture and especially those who filmed their family, there was a sense of ownership and pride in learning and sharing stories about their family. In Moll et al’s (1992) study, teachers visited students’ homes. In large classrooms with a heavy teaching load and concerns of privacy this would be difficult to accomplish. Filmmaking overcomes this by empowering students to build bridges between home and school. In this sense ‘home’ is used to refer to any out of school context such as hobbies (riding bikes, dancing, playing a sport) or family traditions.

Filmmaking gave rise to a new mode in which pupils were able to make sense of themselves and the world around them. Giving the students cameras, a tangible communication device, shifted power from the teacher to student and gave students authority. Incorporating and valuing out-of-school funds of knowledge positioned students and their family as experts. The benefits of validating students and their families has been described by Calabrese Barton & Tan (2009) who said that

…the process of expanding the enculturation process to incorporate reciprocity created new ways of participating in science class that were legitimate and that fostered new opportunities to engage the subject matter that promoted both academic achievement and inclusion. (p. 66)

There was an additional layer of power, authority, ownership, legitimization and pride when students’ films were shown during community screening and students were rewarded with certificates and DVD copies of their film. The depth of pride and family and community engagement was demonstrated when one parent from School Quandong cried when he saw his daughter’s film. She later reported in an interview that her dad was proud of the film she made. One student at School Nyasa mentioned his sense of pride and achievement when students applauded at the end of his film. At each community screening, students were called forward individually and shook the hand of
either the Principal or a distinguished invited guest when receiving their certificate and DVD copy of their film. This public display of recognition further validated students and their families as experts.

It was worth investing in handheld camcorders because students, particularly in Malawi, often mentioned holding the camera was an exciting experience. It is expected that other types of media production such as animating still pictures in digital storytelling or making films with mobile phones will not have the same level of equipment attractiveness and intrinsic appeal.

4.3 Conclusions

Our research is significant in demonstrating how filmmaking that connects science and home worlds engages and empowers students. This research shows the effectiveness of filmmaking as a tool to engage students in exploring connections between science and culture. We recognise that filmmaking in a science class is not easily implementable as teachers may have limited knowledge about filmmaking or may lack resources. There are less resource intensive approaches that can still support funds of knowledge, such as asking students to take photographs, but as mentioned above this may be less attractive to students.

We recommend filmmaking about science and culture as a educational activity. In a classroom setting, we encourage scaffolding and provision of guidance to students in their researching about science and culture. What sorts of scientific questions can students investigate in relation to culture? These may include chemical processes, physical and biological properties. We also contend that films about connections between science and culture should consider representing values, attitudes and beliefs that are recruited in the pursuit of knowledge such as creativity, perseverance and open-mindedness (Stephens, 2003).

Often culturally responsive teaching is relegated to the humanities and social science (Boutte & Hill, 2006). If School Quandong intends to develop cross-curricular subject teaching, as Ms. Carr mentioned, science should be included as one of the subjects. For example Asian studies could include scientific development and cultural knowledge from Asian nations. Incorporating culture is not the only way of achieving engagement
in school (Carlone & Johnson, 2012). Of course students can produce films about science without having to combine it with culture. The advantage of connecting science with culture is it incorporates funds of knowledge and fosters intercultural understanding. This is empowering for students as they make connections between science and their own and other cultures.
Preface

The students in our study drew on a range of funds of knowledge as they produced their films about science and culture. Both being able to incorporate different funds of knowledge and the process of filmmaking empowered and engaged students. An important finding in previous chapters has been students’ understanding of and attitude toward culture. Admittedly, identity as a theoretical framework to examine students’ experiences of science at school was not considered in the original research design. A post hoc assessment of students’ identity was conducted for two reasons. Firstly, identity is increasingly used in science education to understand and improve on student learning experiences. Secondly, use of an identity framework builds on the findings from the previous chapter to show how filmmaking and funds of knowledge can support improved education outcomes. Identity provides a useful theoretical lens in which to interpret those findings from Chapter 2-4. This is discussed in detail in the next chapter.
5 Personal and cultural identity in youth films about science and culture

5.1 Abstract

Identity is gaining popularity in science education research as a theoretical frame to understand student engagement, interest and learning in science. Our unique contribution to the growing body of literature in identity research aims to fill a gap in studies by examining the interface of personal identity, cultural identity, youth and filmmaking. We draw on findings from our research on youth films about science and culture from three schools, two in Western Australia and one in Malawi, Africa. Three themes related to identity emerged from our analysis. Firstly, filmmaking provided students opportunities to try on and imagine scientific identities that relate to their everyday life. Secondly, Aboriginal young people experience tension between their cultural identity and modern society. Thirdly, filmmaking can support intercultural understanding in multicultural societies. These themes are portrayed through stories of two students - Wongani from Malawi and Mickey, an Aboriginal Australian student - as well as interviews with and observations of students and teachers.

5.2 Introduction

The original premise of our research was that filmmaking about science and culture could be used as an activity to engage students in making connections between science and other sources of knowledge like personal, peer, family and community and popular culture. In our previous research, we explored students’ perceptions of and meaning making of the interface between the complex conceptions of scientific and cultural knowledge. Our research activities were group meaning maps, story box activity and filmmaking. Theoretical frameworks used to interrogate results of those activities were practice theory (Eisenhart, 2001), social constructivism (Vygotsky, 1978) and multicultural theories such as border crossing (Aikenhead & Jegede, 1999), third space (Moje, et al., 2004) and funds of knowledge (Moll, et al., 2005). We did not originally consider identity within our theoretical suite. As we reflected on the research process which spanned from training students to create their films to community screenings of those films, we realised that the wealth of data collected (45 group meaning maps, 15 audio recordings of group discussion during story box activities, 44 Venn diagrams, 26
interview and think alouds with students, three teacher/coordinator interviews, 39 short films, and detailed observations) involving 190 students in seven schools in Western Australia and Malawi provided an opportunity to consider and illustrate students’ identities both during the process of filmmaking and in the films that they produced. As identity is an increasingly useful theoretical frame (Aydeniz & Hodge, 2011) for understanding students’ attitudes about and engagement in science, we add our observations to this growing body of literature.

Our research aims to answer the question - what does filmmaking about science and culture reveal about students’ identities? Our study contributes to this area by providing a unique assessment comparing settings across oceans and students who come from different cultures. We begin this chapter with a description of the historical conceptualization of identity, followed by a review of social identity as it relates to cultural identity, and finish by discussing identity as it relates to science education and then filmmaking. The three areas of identity work – filmmaking, science education and cultural identity set the foundation for exploring three themes that emerged from our research: students’ exploration of a scientific identity afforded by filmmaking, Aboriginal cultural identity and intercultural understanding and cultural privileging.

5.3 Identity

“Identities are the traits and characteristics, social relations, roles, and social group memberships that define who one is” (Oyserman, Elmore, & Smith, 2012, p. 69). Identity is increasingly employed in formal and informal science education research as a theoretical rationale to understand students’ interest, motivation and attitudes to science (Aydeniz & Hodge, 2011). Some have said identity has been overused and misappropriated to the point where it has lost its salience, while others argue that its vagueness allows it to be flexible and malleably suited to provide rich insights into learning (Flum & Kaplan, 2012).

Erikson’s (1968) classical psychological account describes identity formation through stages, with each stage characterized by psychological conflict that needs to be resolved in order to proceed to the next stage. According to Erikson, identity formation begins at birth and continues through to adulthood, with adolescence being a critical period. In his seminal book *Identity: Youth and Crisis*, Erikson (1968) spoke of adolescence as a period of crisis, confusion and instability in which adolescents ask critical questions
about themselves, their sexual identity, their careers, values and ideals. To cope with these uncertainties, adolescents may bond with peers in cliques and fantasize about heroes and heroines. The process is iterative with continued reflection and redefining through interaction with peers and significant others. Different groups have different influence. Erikson notes that during adolescence, young people tend to associate more with peer groups and separate from family. This experimentation of youth identity as outlined by Erikson is useful for our analysis.

Marcia (1980) extends Erikson’s account of identity development focussing mainly on adolescence as a period of “identity crisis”. He identified four possible “identity statuses”: foreclosure, diffusion, moratorium and achievement. Identity fore-closed is a status in which individuals obey authority and follow rules and expectations. In a diffused status, an individual will no longer commit to norms and conventions. Moratorium is a period of crisis and experimenting with alternatives and finally achievement involves an individual making a decision about who they want to be. Moratorium status would apply to science education when students try on and commit to scientific roles. However Marcia’s description of identity crisis is a simplification of adolescence which is an iterative and gradual process (Buckingham, 2008).

There is a dynamic relationship between individuals and the social groups they belong to. Through interactions and negotiations with others, identity is experienced (Jenkins, 2004). Erving Goffman (1959 ) referred to this as a theatrical performance with individuals creating impressions that aim to achieve a goal. Goffman used the terms “back stage” and “on stage behaviour”. When “on stage” for example, adolescents in out-of-school settings will comply with standards and act according to social conventions of that particular group. “Back stage”, individuals are their true selves and may even contradict their “on stage” performances. Goffman’s postulation however has been criticized for suggesting that “back stage” is more sincere and for not taking into account personal versus social identity (Williams, 1986).

Another approach to identity is framed in relation to late modern societies. Giddens (1991) described a shift in the nature of identity; while previously identities were strongly shaped by customary beliefs and values (e.g. religion), identities are now less influenced by those factors. In late modern societies individuals have more free will to construct their own identities. In today’s world, Giddens observes individuals are at
liberty to make decisions for themselves on a range of life options and relationships. People take on a wealth of guidance from counsellors, media, popular culture and other sources. In Giddens’ account, individuality is seen as a project with individuals crafting stories about themselves.

Identity-based motivation is a more recent postulation in identity studies (Oyserman, 2007). Oyserman put forward “identity-based motivation” to understand how social, personal and racial identities that comprise self-concept influence behaviours and decision-making. People prefer to act and interpret situations in accordance with active identities or in an identity-congruent manner. Individuals will persevere if the action is difficult as long as it is identity congruent and therefore meaningful. If the action is identity incongruent individuals will perceive that it is not for them (Oyserman, et al., 2012). Where situations cue an identity, this identity is ready to make sense of the world or situation according to the values, beliefs and goals of that particular identity. Experienced stability occurs when people have a sense of who they are, are able to predict their behaviour and thus are willing to invest in their own future. An example of this would be an individual investing time and effort in developing a talent such as music or science.

Amongst these different accounts of identity, there is considerable confusion in the literature on the conceptions of identity and self (Oyserman, et al., 2012). Identity and self are interchangeably used incorrectly. They both influence individuals’ motivations, behaviour and understanding of themselves and others (Oyserman, 2007) but refer to different things. Oyserman et al. (2012) provide a breakdown of self, self concept and identity. They describe self as “I” who thinks and “me” as the content of the thoughts. Self concepts are the content of thoughts of who one is, was and aspires to be. Identity can be considered a way of making sense of self-concepts (Oyserman, et al., 2012; Schwartz, Zamboanga, Weisskirch, & Rodriguez, 2009).

Combining all these psychological constructs, identity can be assumed to be something that is both intrinsic (conception of one’s self) and extrinsic (enacted according to both one’s self and others). Identities are a reflection of the past - who an individual was, the present – who one is trying to be currently, and the future – who one aspires to be.
5.3.1 Social identity and cultural identity

Identity is something that an individual uniquely possesses but is heavily influenced by relationships with social groups (Buckingham, 2008). Social identities as a person’s sense of who they are based on membership in a group was proposed by Tajfel and Turner (Tajfel & Turner, 1986). For example ethnic identity or national identity is a shared concept of self in which the assumption is similarity with others. In this sense people can have multiple fluid identities dependent on social, cultural, and biological characteristics as well as shared values, histories and interests. Social identities relate to one’s knowledge and feelings of membership in a particular group, awareness of the status within that group and that group’s status in relation to other groups. This perspective of social identity theory argues that people take on different identities depending on social context and groups. Through groups, people acquire a sense of pride and self esteem, more so belonging. To increase group esteem, the group enhances its social status or discriminates against other groups. This creates in-groups and out-groups. To enhance self image, the in-group may have prejudiced opinions and negatively discriminate against the out-group (e.g. example middle class and working class) (Tajfel & Turner, 1986).

Another form of social identity relates to identity politics which deals more with a group rather than an individual for example ethnicity, sexuality, gender (Hayes, 2012). Identity politics fixes all individuals within a group as being the same. For example, individuals share a similar biological characteristic or history. Identity politics tends to ignore diversity within a group. This creates binary views (Hall, 1996). For example asserting Aboriginality can be conceived by some as maintaining difference rather than recognition of historical roots. The criticism of identity politics not acknowledging diversity is similar to opposition of the popular pluralizable definition of culture adopted in science education which views culture as “a concrete and bounded world of beliefs and practices” (Sewell Jr, 2005, p. 79). In this view labels are given that differentiate groups e.g. Aboriginal culture, Indian culture. Seiler (2013), a science educator, argues that the multiple discontinuous definition of culture promotes inequitable difference between cultures and uniformity within cultural groups. This view supports tokenistic stereotypical representations of culture which inhibit meaningful intercultural understanding (Trofanenko, 2006).
Cultural identity is built on values and practices, how individuals perceive the cultural or ethnic groups they belong to and the importance of the individual and of the group (Schwartz, Zamboanga, & Weisskirch, 2008). Under these themes a number of cultural identity ideologies can be included: acculturation, ethnic identity, individualism and collectivism, independence and interdependence, obligation to siblings and family, and communalism (Schwartz, et al., 2008). Cultural identity differs from personal identity in representing intrinsic values that are derived from the cultural group i.e. ‘who am I as a member of my group, and in relation to other groups?’ Personal identity defines individuals ‘who am I?’ Cultural identity is considered a type of social identity i.e. specifically belonging to a cultural group based on ethnicity, language or religion (Hall, 1996). Social identity is the representation of internalized group values and the perceived importance of the membership to that group (Tajfel & Turner, 1986). Cultural identity is composed of both individual and group level characteristics.

It is important at this stage to make a clear distinction between race, ethnicity and culture. Race is a social and political construct which categorizes people based on phenotypical characteristics (e.g. skin colour, hair texture) (Bhugra & Becker, 2005). Ethnicity is based on shared values, heritage, language, origins (Bhugra & Becker, 2005). Ethnic groups may or may not comprise the same race. In Bhugra & Becker’s (2005) view of cultural identity, culture consists of shared beliefs and values that are passed through generations, for example language, rites of passage, social roles.

Phinney (1989) proposed a model for ethnic identity development which is underpinned by Erikson’s (1968) and Marcia’s (1980) theories of identity development. Phinney’s model has three stages; a) unexamined ethnic identity is when individuals have not given ethnicity any thought. This is similar to Marcia’s (1980) foreclosure stage where individuals commit to an identity without exploring alternatives or perhaps even being aware of the possibilities of alternatives. The second stage of Phinney’s model is ethnic identity search. This stage is typically characterized by individuals questioning and attempting to understand ethnicity. This is similar to Marcia’s (1980) moratorium and Erikson’s (1968) “identity versus role confusion” stages. The enactment of ethnic identity search may be influenced by a significant experience such as discrimination. This may motivate individuals to actively explore ethnicity through reading books, talking to family members about ethnicity or doing other research. The final stage is
ethnic identity achievement, in which an individual has a clear understanding of the role of their ethnicity in their life.

Phinney (1992) went on to develop the Multigroup Ethnic Identity Measure as a scale to measure ethnic identity. The Measure assesses three aspects: affirmation and sense of belonging; ethnic identity achievement, based on exploration and commitment; and ethnic behaviours or practices, related to participation in customs and traditional activities. This instrument has been tested for reliability and validity and is the most widely used tool for measuring ethnic identity (French, Seidman, Allen, & Aber, 2006).

Race, ethnicity and culture form part of an individual’s identity. Bhugra, a cultural psychiatrist, has written at length on the impact of migration and cultural identity, particularly as they relate to mental health (Bhugra & Arya, 2005; Bhugra & Becker, 2005). Immigrants and minority groups experience mental stresses that significantly affect their identity. Immigrants may experience assimilation or acculturation. During assimilation, an immigrant will lose their cultural identity and adopt the culture of the host or dominant community, eventually becoming completely absorbed in the dominant group. Acculturation is less severe, with immigrant communities adopting the majority group’s customs but remaining as a distinct minority group. Understanding these processes of acculturation and assimilation and their influences on personal identity and cultural identity can give insight into immigrant and Aboriginal student experiences and behaviours. The processes of assimilation and acculturation have been adopted in describing multicultural science education, as discussed in Chapter 2.

5.3.2 Identity in education

Noting the utility of identity as a theoretical tool to understand behaviour and decision-making, education scholars have applied identity to science learning. Gee (2000) focuses on individual identity and roles in community. He defines identity as “being recognized as a certain ‘kind of person,’ in a given context…” (p.99). He offers four views of identity based on social and cultural perspectives: N-identity (nature), I-identity (institutional), D-identity (discourse), and A-identity (affinity). N-identity covers features that cannot be controlled, for example physical appearance or sex. I-identity relates to institutions, (e.g. academic titles like professor, doctor). D-identity is based on social interaction in a community (e.g. caring). Shared experiences create A-identity (e.g. joining voluntary specialist clubs like bowling clubs). These views are
interrelated and act dynamically. Gee’s four views of identity have been applied in examining students’ discourse. In assessing discursive identity - a modification of D-identity - Brown, Reveles and Kelly (2005) studied fifth grade African-American students construction of scientific identity and found language is closely associated with students’ participation in science.

Aydeniz and Hodge (2011) argue that identities are formed in relation to something such as policy or context. There are times when a person’s core identity prompts them to pursue a specific agenda. For example not all students who study tertiary level science should be considered to have a core scientific identity. People have many reasons why they choose to study science such as better job opportunities. However people who go on post study to work as practicing scientists do identify personal reasons (“I am interested in science” and “I am good at science”) as the main motivation for their choosing to study science (Venville, et al., 2013).

Other frequently cited identity research is that done by Lave and Wenger (1991). Lave and Wenger (1991) situate their formulation of identity in “communities of practice”. They state that learning that occurs in communities of practice is analogous to apprenticeship training, whereby in order to gain access to a professional group, the apprentice models behaviour, skills and knowledge on the master. Belonging to communities of practice occurs through three modes: engagement, imagination and alignment (Wenger, 1998). Engagement is active involvement in the community. Imagination is picturing oneself in the future based on experiences. Alignment is taking decisive steps to that imagined identity such as enrolling in training courses. These three modes provide constructive approaches in which to support students’ science learning. In other words a process of engagement in learning must occur followed by opportunities that support students imagining themselves in scientific roles and then alignment to scientific identities.

Communities of practice is the dominant framework in which science education studies are interpreted. In Tan and Calabrese Barton’s (2008) ethnographic study of two Latina students in an urban low income community, they use identities-in-practice to describe the learning and concomitant transformation as students acquire scientific identities in the science classroom. They consider that individuals have several identities that are enacted when seeking membership into communities of practice such as science. These
identities are valued and positioned differently based on societal structures and power relations. Membership into the community of practice is a process of negotiating tensions across these repertoires of identities. Tan and Calabrese Barton’s (2008) prefer identities-in-practice rather than identity to describe the contextual factors in the classroom that influence identity formation, for example relations between the teacher (authority figure), good students and novice students. The process of forming and negotiating identities-in-practice is reflected in student’s questions, opinions, interactions with other students and level of participation (demonstrated in filmmaking by students recruiting peer funds of knowledge, as discussed in Chapter 4). In Tan and Calabrese Barton’s (2008) study, two 6th grade female students author non-traditional scientific identities, one by using popular culture to write a song on bones and the other using worm poop to engage in classroom discourse. The researchers use the concept of agency to describe a sense of purpose in the girls authoring new identities-in-practice which positioned them with more power to engage in their science class. One student, Ginny, merged multiple identities “popular, generous girl”, “pop-culture consumer” and “good science student”. To help revise for a test, she wrote a song about bones using a pop song and then shared it with fellow students.

Brickhouse, Lowery and Schultz (2000) argue that teaching often aims to promote scientific identities that resemble research scientists, however research scientists as a community of practice are too remote for students. Communities of practice have to be accessible and relevant to students, for example having a parent who works in science. Scientific communities of practice need to be more open to “members” and not just limited to research scientists but also include people who practice science or use scientific principles, such as mechanics and chefs. This resonates with Hector, a participant in Kozoll and Osborne’s study (2004). Hector, a Mexican immigrant, did not connect science with his life, despite coming from an agricultural community, where opportunities existed to consider science in fertilizer, pesticides and crops. For Hector, science was relegated to a school subject that had no applicability or relevance in his daily life.

Engagement, another of Wenger’s modes of belonging to a community of practice, is commonly used in science education linked to student achievement (Furrer & Skinner, 2003). Engagement has been defined as “active, goal-directed, flexible, constructive, persistent, focused interactions with the social and physical environments” (Furrer &
Skinner, 2003, p. 149) and is related to how one constructs self in relation to others in particular social contexts. Engagement is associated with a sense of belonging and identity such that when identities are linked to social contexts then individuals are more likely to engage and learn more (Nasir & Hand, 2008). Nasir and Hand (2008) use practice-linked identities to connect self and practice. These are identities that people adopt in order to participate in a given social and cultural context.

Engagement can be characterized by level and intensity of participation (Furrer & Skinner, 2003). Nasir and Hand (2008) observe that because of their structure, standards and rules, practices allow for different levels of engagement and performance of different practice-linked identities. They proffer that in practices where persons feel a sense of closeness they are more likely to participate and deeply engage. This premise is similar to identity based motivation where individuals persist if an action is meaningful and identity-congruent (Oyserman, Fryberg, & Yoder, 2007). Migrant students had a sustained engagement with science and adopted scientific identities when science was presented as applicable to their everyday lives (Kozoll & Osborne, 2004).

Access to communities of practice was explored in a study on mathematics and basketball (Nasir & Hand, 2008). The authors reported that classroom learning in mathematics compared to playing in a basketball team was less engaging for students because students had limited opportunities in the maths classroom to access, role play and express themselves in the subject. This led to students feeling less confident and disengaging from the subject. Access, role play and expression are similar to Wenger’s three modes accessibility, imagination and alignment (1998). In order to support meaningful learning, the authors of the mathematics and basketball study argue for opportunities for students to take on practice-related identities (Nasir & Hand, 2008).

The science education research literature is replete with identity studies (Aydeniz & Hodge, 2011). However there are gaps in research on the impact of larger social structures on identity. In a review of science education identity research, Shanahan (2009) argues for more studies that investigate how larger societal frameworks (i.e. social structures) influence identity. She employs Côté and Levine’s (2002) Personality and Social Structure Perspective (PSSP) three levels of analysis: personality, interaction and social structure. Personality is related to self. Interaction refers to an individual’s day-to-day activities and communication with others. Social structures are dominant
frameworks and social norms within societies. Using these three levels of analysis, Shanahan (2009) reviews a number of science education identity studies and observes a bias towards personal and interaction levels. She argues the community of practice theoretical framework does not support exploring social structures. Shanahan proposed two frameworks to extend identity work to social structures: hybridity and cultural-historical activity theory. Hybridity investigates personal and interaction levels. However, Shanahan’s definition of hybridity is imprecise and not well differentiated from communities of practice. Cultural-historical activity theory, in its broader scope, has more to offer.

In cultural-historical activity theory, identities create activities (e.g. school science) and in creating activities social structures are constructed. In her review, Shanahan (2009) discussed two studies that applied cultural-historical activity theory. However she does not provide strong evidence for how cultural-historical activity theory can be operationalized in research. She contends that studies need to investigate how norms, expectations and rules are developed and adopted in societies and how social structures differ in other environments like home and in informal settings. She fails to note studies on the influence of larger social structures on African American youth such as “acting white” (Fordham & Ogbu, 1986), stereotype threat (Steele & Aronson, 1995) and “The Obama Effect” (Marx, Ko, & Friedman, 2009). Understanding how norms are created can provide mechanisms to challenge negative norms and create more stable and positive social structures for students to construct scientific identities.

There exist a variety of tools for measuring identity. Psychologist favour quantitative approaches such as questionnaires whilst anthropologist prefer ethnography, in-depth interviews and longitudinal studies to interrogate identity formation (Kroger, 2007). Scholars have argued against quantitative snap-shot measures of adolescent identity; increasingly a mixture of qualitative and quantitative measures are encouraged depending on the nature of the study (Kroger, 2007). Shanahan (2009) argues for using quantitative approaches to study social structures. Shanahan asserts that quantitative measures are not aimed at quantifying identity but rather looking at patterns within a large social framework.
5.3.3 Identity in youth media

Although there is a growing body of research on how youth use media, there is only limited writing on youth media and identity (Buckingham, 2008). Analytic frameworks exploring digital media composition and identity hold promise (Halverson, 2010; Hull & Nelson, 2005); both these approaches draw on multimodality. Semiotic modes of communication include text, video, and sound effects. Multimodality is “the use of several semiotic modes in the design of a semiotic product or event, together with the particular way in which these modes are combined” (Kress & Van Leewen, 2001, p. 20). The combination of different modes creates new meaning.

Halverson’s (2010) proposed framework combines analyses of social semiotics of multimodal products with youth media intervention programs and visual analysis of films. The units of analysis in Halverson’s approach are transitions and phases. Phases are similar to sequences (a series of corresponding shots) and transitions are the spaces in between phases. The coding scheme she proposes is based on four key cinematic techniques- mise en scene, sound, editing and cinematography. In her analysis of a documentary film titled Rules of Engagement by a Muslim American teenager, her analysis of mise en scene (i.e. anything within the frame of the camera), reveals the subject’s tension living in two different worlds, one world in a devout traditional Muslim family and the other in a westernized modern American.

Narrative is frequently described as an approach to understand youth authored media. Jocson (2012) uses the term “narrative assemblage” to describe ways in which youth use stories and art to make meaning, represent that meaning and communicate it to others. It merges assemblage (Waldman, 1992), borrowed from art, where objects are brought together to create a new art piece and narrative, the reconstruction of reality through storytelling (Bruner, 1991). Through narratives one can glimpse personal lives and histories. Joscon applied this concept to a ninth grade social studies multimedia project about migration and immigration. Jocson does not attempt to explore identity within narrative assemblage but rather focuses on pedagogical outcomes such as new media literacies.

A longitudinal digital storytelling project in Singapore merged identity with art (Wales, 2012). Wales (2012) describes how a digital storytelling project created opportunities for young people to improve their digital literacy and explore and represent their
identities. During the three and a half year project, the multimodal products created by an at risk youth allowed him to try on many different roles/identities – author, coordinator, mentor, teacher, director and camera person. Gallagher (1997) observes that narratives allow students multiple opportunities for exploration, realities and ways of knowing. By analysing narratives we can understand social structures that shape identities and by understanding them we can explore ways in which to transform people. Narratives and filmmaking in this sense are reminiscent of Nasir and Hand’s (2008) access, role play and expression and Wenger’s (1998) accessibility, imagination and alignment (1998).

There are few studies that fuse identity, youth, filmmaking and science. One study by Furman and Calabrese Barton (2006) used voice to explore how two students constructed identities in an after school filmmaking program. They determined that encouraging student voices in science projects could support the development of scientific identities. They too draw on Wenger (1998), where learning is a gradual construction of identities that allow students to become members in different communities of practice which align with who they are and who they want to be. Furman and Calabrese Barton (2006) contend that voice, the ways in which students speak and express themselves, reveals whether science has become part of their identity. They worked with youth in creating short films about science during a voluntary after school science program. Student voices were captured through the films that students produced, field notes and interviews. Youth participants were allowed to choose any topic but had to explain why their topic was scientific. Students were given freedom in producing the film including discussing their roles in the film, the length of the film and when and how often to meet up after school to produce the film. Allowing students independence provided the researchers an opportunity to interrogate student voices and motivations that gave insight into identities.

Filmmaking engaged students, gave student ownership and allowed them to express themselves in their own terms whether through song, dance or other forms (Furman & Calabrese Barton, 2006). Choice and independence created several possibilities for students’ voices to be expressed. Based on the findings of their study, Furman and Barton recommend three strategies for improving student science learning outcomes. Firstly, the project should provide opportunities for integrating student perspectives, not simply providing day to day examples but enabling students to take up central roles or
expert roles in science. Secondly, the project should cultivate student participation by
giving students choice and opportunities to make their own decisions (e.g. student
choosing the format of an assessment - oral presentation, video, podcast). Providing a
choice does however have to be guided by teachers to insure informed and valued
decision-making. Their third recommendation is to assess learning through “changing
voices” as opposed to the standard assessment techniques. They recognise that
assessments of “changing voices” would be challenging but could be aided by
examining student work, participation and use of non-formal resources. “Opportunities
to express one’s voice can enhance participation in a learning community in which one
may have previously been excluded or chosen not to participate.” (Furman & Calabrese
Barton, 2006, p. 691)

5.3.4 Identity, youth, science, film
We interrogate findings from the above theoretical frameworks to examine findings
from our research. We employ Lave and Wenger’s (1991) communities of practice and
three modes: engagement, imagination and alignment to understand how Wongani, a
Malawian student from a deprived socio-economic background, authored and
represented his scientific identity in his film. Wongani’s scientific identity is further
explored through Tan and Calabrese’s (2008) identities-in-practice and Nasir and
Hand’s (2008) practice-linked identities. Communities of practice (Wenger, 1998) and
practice-linked identities (Nasir & Hand, 2008) together with social and cultural identity
(Phinney, 1989; Tajfel & Turner, 1986) are employed in describing the multiple social
identities of Mickey, an Aboriginal student with conflicting identities. We then attend to
intercultural understanding and cultural privileging through Phinney’s (1989) ethnic
identity development and social and cultural identity theories.

5.4 Methodology
In our research on student-generated films about science and culture, we worked with
three schools, two in Western Australia and one in Malawi, Africa (as described in
section Chapter 4, section 4.4.1). Data were collected through student and teacher or
coordinator interviews, analyses of student films, observations during class and field
notes. Research activities: group meaning maps and story box activity, were also
conducted at all three schools (Chapter 2, 3 and 4). Pseudonyms have been used in
place of actual school, student and teacher names.
School Nyasa in Malawi is comparable to Western Australian schools for a number of reasons. It is a private school that was established as a premier international centre of excellence. School Nyasa in its bid to be an international academy adopted the Cambridge Graduate Certificate of Education instead of the Malawi curriculum. With support of philanthropists in the US and in Malawi, scholarships are offered to orphans and vulnerable children. The school also has fee-paying students who come from middle-high income families. Twenty one students in the Year 9 class at School Nyasa participated in the study, producing 18 short films.

Aboriginal students in the Follow the Dream program at School Quandong participated in this study. Follow the Dream is an after school homework program for aspiring Aboriginal students. School Quandong is located in a mining town in a regional centre. Although mining has created an influx of other ethnic groups living and working in the area, the town maintains a large indigenous population. The coordinator of the Follow the Dream program recognised that positive outcomes for students were contingent on the coordinator developing personal relationships with both the student and their guardians. She organized a number of extension activities, personal development workshops and excursions to build student confidence and self esteem. Eighteen students in the Follow Dream program participated in the filmmaking project, producing 11 videos.

School Rainbow is a metropolitan primary school with a diversity of cultures. Of the 469 students in 2011, 42% had a language background other than English. Fifty four languages other than English were spoken by students at the school. The neighbourhood reflects the cultural diversity with a number of Bulgarian, Polish and Sudanese ethnic community clubs. The cafes, shops, hair salons and restaurants similarly display the multitude of cultures - Chinese shops, African hair salons, Indian restaurants and Italian cafes. The Headmaster at the school during our first meeting pointed to a banner in the school’s reception, which declared the school embraced and celebrated cultural diversity. The Year 7 class at School Rainbow participated in the study. The entire class of 30 students participated in the filmmaking program. They worked in groups of three to produce 10 short films.
Students were given training in camera operation, filmmaking and editing. At School Quandong and Nyasa, students produced individual films but at School Rainbow due to the large class size and a shortage of cameras, students worked in groups of three. The schedule for training varied at the different schools but the content delivered was the same. At each site, student films were shown during a screening where family, friends and staff were invited and certificates of completion awarded to students.

To answer the research question - what does filmmaking about science and culture reveal about students’ identities? Two students, Mickey and Wongani were purposively selected as information rich extreme or deviant cases (Patton, 2002). Deviant cases highlight successes and failures that provide useful insights on best practice. The two students illustrate different extreme experiences of trying on scientific and social identities. On the one hand Wongani is an exceptional science student on the other hand Mickey prefers opportunities to express himself through dance. Thematic analysis was applied to these two cases as well as holistically to the aggregated data set of interviews, observations and films. The analysis was theory driven. Theoretical frameworks: social and cultural identity, identities-in-practice, practice-linked identities and communities of practice were applied to the data.

5.5 Findings

Drawing from identity research principles and applying them to our study, we discovered three thematic areas. Firstly, filmmaking enabled students to construct and represent scientific identities. We illustrate this by describing one particular student, Wongani from School Nyasa. Secondly, we note the differences between a dance club and science class in supporting practice-linked identities. We depict this by sharing narratives of Mickey, an Aboriginal student from School Quandong. Thirdly, we report on tensions between Aboriginal students’ cultural identity and modern society. In addition to in-depth descriptions of these two students, we considered perspectives and observations of other students and teachers from these schools and School Rainbow.

5.5.1 Wongani

At the time of this study, Wongani was a quiet, studious, fourteen year old student. His father had passed away and his mother lived in a high density area near the city. He was a recipient of a scholarship to attend School Nyasa. The scholarship paid his school
fees, uniform, books as well as his boarding fees at School Nyasa’s boys’ boarding house. School Nyasa’s goal on launching in 2009 was to be a premier international academy. Having students sit English and Maths entrance exams and charging expensive school fees set high standards. Fees were $510 per term, which was beyond the average Malawian, with GDP per capita in Malawi of $902 in 2010.

The founder of School Nyasa, a Malawian lady who lived overseas, Mrs. Locke, also supported a community based organization, Nyumba, that assisted orphans and vulnerable children and women. Nyumba’s programs included helping women with income generating activities and providing meals to young orphans. Mrs. Locke raised funds for school fees and upkeep of disadvantaged children from Nyumba. Most of the children at Nyumba attended local government schools where the standard of education was low. In order for children from Nyumba to pass the entrance exams at School Nyasa and therefore be at the same level of literacy and numeracy as the fee based students at the school, Mrs. Locke arranged for an international volunteer to provide intensive workshops on Maths and English. At the end of three months of teaching the children at Nyumba, the volunteer was invited to select the top five students who “when you teach them, they are making you proud” (statement from a scholarship recipient). Wongani was one of the students who was selected to sit the entrance exams for School Nyasa. Wongani passed the entrance exams and was awarded a scholarship.

Students and the science teacher at the school (who was also the deputy headmaster) repeatedly commented that Mrs. Locke would tell children at Nyumba if they worked hard they would win scholarships to the prestigious School Nyasa. Hard work and a good education were touted as ingredients for a successful future. Good grades in science at school were also heavily promoted at School Nyasa to lead to successful careers and a prosperous future.

* I made it a priority that students appreciate the fact that science is one of the key subjects and that if they want to study other subjects, science related subjects, they will need to have strong passes in science related subjects in school.*  
Mr. Nyirenda, teacher and deputy headmaster at School Nyasa

Students at School Nyasa reported good grades in science were important for securing a job or career.
Science can help you know more, be educated, can help you in the future with a job. MI, School Nyasa

I like science because my ambition is to be a nurse. MN, School Nyasa

Other students at School Nyasa often referred to Wongani as the model student, “top science student”, “star pupil”. Wongani was the only student who featured in two other films. One film was a chemistry experiment to determine which dissolves faster in water, salt or sugar. The other film was on African drumming. Both times, the students had asked Wongani to participate in their films because he was the “star pupil” or the “best drummer”.

Wongani is the star for the whole school. He is the only [one] that I admire. If I was like him I would be doing great achievements. His will is “I should do that thing”. What he always does when he is alone, you might find him writing in a notebook or revising. His aim is “I am here at School Nyasa. I should do what I came here for”. Everyone looks up to him.” MC, School Nyasa

Despite all the praise from other students, Wongani was a humble, timid student, who worked quietly and diligently. Wongani produced a film titled Forces in Action that demonstrated pulling and pushing forces and gravity. His film featured many different activities: a girl washing plates, a boy playing football, himself jumping off a building, boys play fighting and a boy sweeping. In his interview, Wongani said he got advice from friends on ideas for his film. One of the close friends that he mentioned was a classmate, who was another hard working student on a scholarship.

The tone of Wongani’s film was humorous; for example he sped up the movie when boys were play fighting and had ketchup coming out of his mouth when he was hit in slow motion. Compared to the 38 other films produced by students involved in this project, Wongani’s film had the greatest number of sequences and different locations. Most students only filmed in one location e.g. kitchen, science laboratory, dining room, or park. To illustrate physical forces, Wongani filmed his neighbour washing plates at her house, himself jumping off the wall of the boarding house, boys fighting in the
garden, interviewed a friend on the veranda, another friend playing football and another friend sweeping inside the house.

During filmmaking and editing workshops, he remained transfixed at his desk. Other students during editing would often walk around the computer room checking what their classmates were doing or showing off bits of their footage but Wongani would remain at his desk with his headphones on, editing. He would often come to the computer room during lunch and recess to edit. The quality, script and editing in his video were exceptional compared to those of other students. Other students commented that Wongani’s film was their favourite. He was a perfectionist, tightly editing his film unlike the other students. He was only willing to help his classmates if it did not jeopardize his own work. One student asked him to re-film his drumming solo but Wongani declined, preferring to work on his editing. Wongani found editing the hardest part of the filmmaking process but he enjoyed it.

When asked what he learnt during the process of producing the film,

I discovered some forces myself which I had not understood before but when I did try to do it myself, practical, I understood them.

He chose to produce a film about forces because…

I like forces because I know we use them everyday in life as in walking, everything involves forces. I started liking them when we were being taught by Miss. England cause she is the one who explained better to me how we use the forces.

Wongani would apply scientific knowledge he learnt at school to activities at home.

After I learnt about those reactions [e.g. how heats affects particles dissolving], I started relating those reactions to make experiments at home and I found out that culture and science can relate…. When my sisters are cooking and they are away, I do my own tests. When we do experiments for forces. I can go home and when I hear a noise like someone pushing a bed, I imagine frictional forces.
During the course of filmmaking, Wongani said he gained the confidence to act in front of the camera. “Before I was very shy to do something in front of people.”

Wongani’s story parallels that of Clara, a student in the study by Kozoll & Osborne (2004). Both these students are from less privileged backgrounds than many of their peers and have embraced education as a way to a successful future. Wongani was so devoted to his studies that even outside of school hours he was thinking and reading about science. Ms. England, the former science teacher, supported Wongani’s trying on of scientific identities. Using everyday examples to explain forces or factors that affect the rate of dissolution provided a means in which Wongani could try on scientific identities at home and access science communities of practice (Wenger, 1998). Wongani’s scientific identity was cued both in and out of school as he conducted his own experiments at home and as he made observations and understood how science could explain forces at work when “someone was pushing a bed”.

Science was both a part of Wongani now and the person he wanted to become in the future. Wongani had proceeded through all three modes of belonging from engagement and imagination to alignment (Wenger, 1998). He was taking decisive steps to his imagined self as a scientist. He was willing to expend the effort to tightly edit his film because these activities were congruent with his identity of interest in science, dedication and hard work (Oyserman, et al., 2012). Wongani’s hard working model student identity and scientific identity shaped his participation, level of participation in class, aspiration and defined his imagined future self as successful.

We suggest that the ways in which science was taught to Wongani supported his engagement where his sense of self and science positively interacted. Science was a way for Wongani to understand his everyday world. He was able to bring different contexts and experiences together in his film. Science provided meaning and had a place in Wongani’s worldview. He related to science in a way that would advance his education, such that science was a source of inspiration for him and occupied a formative position in his life.

The mindset of hard work and educational success was encouraged and praised at Nyumba, the community based organization and at School Nyasa. This is very different to African American contexts where hard work is considered “acting white” (Fordham
& Ogbu, 1986). Hard work and dedication were particularly important for Wongani, coming from a less privileged background and having the opportunity to attend a prestigious school like School Nyasa. In Wongani’s class of 22, there were six other scholarship recipients. Mr. Nyirenda, the science teacher and deputy headmaster commented that scholarship recipients were highly competitive and that they inspired fee-paying students in the class to work hard. Wongani’s model behaviour rubbed off on other students, including girls, who commented on aspiring and imagining themselves to have Wongani’s attitudes and achievements. Students that work to attain good grades in science but do not attempt to develop a scientific identity may have specific motives, e.g. entrance to university (Aydeniz & Hodge, 2011). Parents, teachers and peers play an important role in students’ achievements in school by inspiring, praising and motivating students to learn (Bouchey, 2004).

It is interesting to note that Wongani’s identity is framed as hardworking science student rather than as a less privileged student, the former supporting his engagement and interest to maximize opportunities and have a better future. This identity could have been nurtured at Nyumba and School Nyasa, as both institutions were new initiatives with explicit objectives of providing opportunities for student development. Wongani also presents himself as a fun-loving student; his was the only student film at School Nyasa where obvious attempts at humour were made.

Wongani used his film to represent his scientific identity. Filmmaking and crafting narratives on science and culture align with Furman and Calabrese Barton’s (2006) recommendations. Filmmaking in this project supported students taking on central or expert roles. Filmmaking enabled students to imagine, access and try on scientific identities. Students expressed themselves using different genres, music, editing techniques, costumes, locations and dialogue. The format of this filmmaking program where students were given authority to choose their topic on science and culture also supports Furman and Calabrese Barton’s recommendation on cultivating participation. Participation and engagement were encouraged by allowing students to present their own interpretations of science and culture. Imagination and creativity were stimulated during training for this project through presentations on elements of a good story and storyboarding.
Wongani appeared to be intrinsically engaged in science learning and using science as a lens to interpret his everyday experiences. We assert that this was cultivated by his previous science teacher who taught science relevant to Wongani’s everyday life. For other students who did not have scientific identities, the process of filmmaking was transformative, through students coming to know that science and culture connect, and that science has a place in everyone’s culture. Filmmaking about science and culture that allows students to make their own decisions, mindfully supported by a facilitator, creates opportunities for students to access, imagine, role play and express scientific identities that relate to their everyday lives.

5.5.2 Mickey

Mickey is an Aboriginal student who was in the Follow the Dream program at School Quandong at the time of the study. Mickey was thirteen years old, a disruptive student who always talked in class and disobeyed orders from teachers, tutors and the coordinator. He liked to provoke arguments, taunt other students and often said what was on his mind. Mickey can be described as theatrical: he spoke with an effeminate voice; had effete hand gestures and gait; always sat with the girls and would openly make comments about cute, sexy male celebrities. He had grown up locally and hated the local area because there “are not many opportunities”. He aspired to be a choreographer. The coordinator of the Follow the Dream commented that Mickey was academically capable but lazy, a troublemaker who only exerted effort and interest in becoming a dancer.

Mickey reported in his interview that he had been dancing all his life. His passion was contemporary music and hiphop dancing. His Aunt had been a choreographer and his Uncle was a professional dancer. Mickey loved dancing because “it just lets me express my emotions and it’s a lot of fun.” His film was about a local dance club. Every Friday after school, Mickey attended a local dance club for adults, adolescents and kids. At the dance club, Mickey was one of the youth leaders. He would choreograph routines for kids. One of the activities in the dance club was the confidence walk, “head up, chest out and walk straight up and at the end pose. It’s just to show confidence in your actions and positive attitude.” Mickey further commented that the confidence walk, dance battles of boys versus girls and freestyling all encouraged kids to express themselves and be confident.
Because most of these children here don’t really like express their actions, they all shy and all that, so they are stepping up to another level becoming individual leaders.

At the dance club, Mickey had access to experts. The manager of the dance club, his wife and child were professional dancers. Mickey was apprenticed into learning different dance styles through observing experts during his regular attendance at the dance studio. He was given responsibility for carrying out important tasks of the dance club such as choreographing the children’s routines. This scenario is analogous to apprentice-expert relationships in communities of practice (Lave & Wenger, 1991). Dancing and the dance club engaged Mickey; he had feelings of competence and mastery and a sense that his membership in that club supported and valued his unique self (Nasir & Hand, 2008). Mickey’s interest and engagement in dance can be understood through Nasir and Hand’s practice-linked identities (2008). Firstly, the dance club provided access to learning dance skills through the knowledge of experts. Secondly, Mickey was given an integral role as youth leader. He was accountable to young students, instructors and parents. Thirdly, dancing and the dance club supported Mickey’s self expression. He was provided and took opportunities to display his competency, mastery and in doing so made a unique contribution and was valued.

He spoke enthusiastically about his dance club and working with kids. This identity of a dance leader was diametrically different to that of his school identity as a disruptive, outspoken, lazy student. Mickey enacted his multiple identities in different social contexts. Membership in the dance club was an important aspect of Mickey’s social identity. The dance club enabled him to express himself, whilst at school he acted out against the rules and standards that prohibited his self expression, perhaps explaining his disruptive behaviour and tendency to speak out of turn.

Mickey said he felt constrained by the lack of opportunities in town and school to engage in expressive forms. For Mickey the absence of a medium of expression at school hindered his meaningful engagement at school. He said he did not like science because his teacher was not any good.

Well at this school we don’t have a very good teacher. So like, yeah, I’m thinking I don’t really like it [science] as much.
However Mickey reported that he had liked playing with ball and stick atom models in science class.

*The atom was pretty fun part for me. I enjoyed mucking around with it.*

Putting together different compounds with ball and stick atom models as a visual, creative endeavour may have connected with Mickey’s expressive personality.

Mickey typifies practice-linked identities. The dance club – similar to the basketball team in Nasir and Hand’s study (2008) and unlike school and science class – was able to deeply engage Mickey because it provided access to knowledge and skills, offered opportunities for Mickey to take on central and valuable roles and provided a space in which Mickey could express himself and make a unique contribution. Mickey could have enjoyed science at school if he had access to an expert or community of practice and science lessons and activities which stimulated and supported his creative, expressive identity.

**5.5.3 Aboriginal cultural identity**

Our final theme is Aboriginal cultural identity. In student responses and actions we observed a recurring pattern where students in the Follow the Dream program spoke of Aboriginal pride but expressed limited knowledge of Aboriginal culture. We begin this discussion by continuing our story of Mickey, shifting our focus from his social identity in the dance club to his cultural identity. This discussion is enhanced by presenting our findings from other Aboriginal students.

When the interview turned to questions on Aboriginal culture, Mickey spoke with less enthusiasm often referring to “indigenous people” as though he was not one of them – “They [Aboriginal elders] should tell them [children] about their culture”.

Unlike a number of Aboriginal students in the Follow the Dream program, Mickey was local. He was born in the area and had access to a long ancestral history. When asked if he participated in any cultural practices, he mentioned some language and listening to his grandmother’s stories.
Well right now my family goes to traditional meetings. They want me to get more involved in going to those. Going out camping and bush and looking at bushtucker and other stuff. Mickey, School Quandong

He commented that culture was important but he did not mention his Aboriginal identity in the same passionate terms as dance. Mickey is a fair skinned Aboriginal student. On more than one occasion he was observed mocking Aboriginal dance. Footage was found on one of the cameras of Mickey parodying Aboriginal singing and dancing with twigs as clapping sticks. Another student in her interview referred to Mickey as a “coconut” – black on the outside, white on the inside.

There is this one Aboriginal boy [she does a Mickey flicking hair imitation], he doesn’t like the Aboriginal stuff. He does not like dancing, the culture, he doesn’t like any of it. He says that he is a coconut. Sometimes he calls himself a penguin cause they like black on the outside and they have a white tummy. He is like proud to [be] Aboriginal and that but he does not want to do anything. He is afraid maybe, he is a bit shame of his culture. He would like to do something with his culture but probably afraid of it, what other people might think maybe. HR, School Quandong

A two and half year study of 14 Aboriginal young people transitioning from primary to secondary school found they drew strength and pride from being Aboriginal (Nelson & Hay, 2010). Social identity is achieved when an individual is aware of their belonging to a group and also perceives a value of belonging to that group (Tajfel & Turner, 1986). The intensity of an individual’s cultural or ethnic self awareness depends on larger societal structures such as the extent of assimilation or whether they visibly look different from the dominant ethnicity in their society (Germain, 2004). In her autobiography, Aboriginal author Sally Morgan (1987) describes how her mother and grandmother deliberately kept her Aboriginal heritage a secret from her by telling her as young girl that she was Indian. In a study of four hundred adolescents, children from minority groups who reported “looking” white were more likely to identify with Anglo-Australian identities (Germain, 2004). It is not clear to what extent “visible ethnicity” played a role in Mickey’s cultural identity as he was fair skinned. Mickey may have adopted a stance similar to what Germain (2004) interprets of Alipuria’s differentiation of race, culture and ethnicity “although one may identify with being Italian, one may
not necessarily look to the “Italian way” of doing things and thinking as a frame of reference for one’s lifestyle” (p. 140).

Similar to Mickey, a number of students in the Follow the Dream program expressed pride in Aboriginal culture but would feign disinterest in their own family histories. Another female student, HI, from the same local area had a long, rich family history. The program coordinator encouraged her to make a film about her grandfather who had buildings named after him but she instead, at the last minute, made a film about the Follow the Dream program where she interviewed other students. This illustrates Erikson’s (1968) description of adolescence as a period when young people tend to associate more with their peers than their family. Another student who interviewed her Grandmother for her film did not attend the screening. When asked, she said that she had to babysit but other students said she was “shame of her Grandmother”.

HR at School Quandong intended to make a film about Aboriginal dancing. “I would like to but I just didn’t really want to” indicating her mixed feelings about the topic. In her interview, she commented that she did not like Aboriginal dance, “Cause I don’t really like Aboriginal dancing. It is kind of different.” She did not produce the film.

*Cause my cousin, he was being silly on it and he deleted it himself. It must have been shame. He didn’t really want to do it. He must have done it when I was sleeping. He must have deleted. Don’t know why. Yeah. HR, School Quandong*

However other students suggested that she had recorded her Auntie’s Aboriginal dance and her brother speaking an Aboriginal language but was ashamed to show this to other students and made up the excuse of her cousin deleting the video.

‘Shame’ is a term used by Aboriginal people to describe situations when an individual is singled out. Whether a person is being commended or reprimanded, the person will feel anxious and uncomfortable (Harkins, 1990). Teachers have expressed concern that shame is a barrier to Aboriginal educational success because students fear excelling in the classroom (Harkins, 1990). Shame is culturally embedded; for Aboriginal people the group is more important than the individual (Harris, 1980) and overt gestures of being better than others are considered showy and are frowned upon. This is in stark contrast
to the Malawian students at School Nyasa who strove to work hard, receive praise and academic recognition. Fear of excelling because of shame is similar to the situation of African American at risk youths’ attitudes towards hard work as “acting white” (Fordham & Ogbu, 1986). In a review of school outcomes and Aboriginal identity, Purdie et al (2000) have reported on “a culture among many students of ‘anti-intellectualism’, of doing well in school as being of little value or something to be ashamed of” (p. 19).

Aboriginal students in our study told us that they did not know much about their culture. They were unable to articulate what being Aboriginal was besides coming from an Aboriginal family. The students revealed the extent of their practicing Aboriginal culture related to law and occasionally going out bush, hunting or fishing.

*We don’t really celebrate anything except for Christmas and that. We go to the river sometimes and cook damper and kangaroo stew and that. We sometimes camp there and enjoy it.* HR, School Quandong

*Sometimes hunting, going out shooting with my dad and granddad. He teaches some stuff like how to find fresh water, how to cook up some emu, goanna, kangaroo. Yeah, he teaches us a lot of stuff. But we don’t do Aboriginal stuff though.* HD, School Quandong

*I am not shy of talking about it [Aboriginal culture]. But sometimes I am because I don’t really follow the culture. Like I don’t go and do stuff out bush like law and all that. I stay in Hedland. My mum does not do it and my family does not do it. Like my whole family does not do it.* HI, School Quandong

Aboriginal cultural identity is fraught with complications and tensions. The varying degrees of knowledge of Aboriginal culture could be explained by students whose grandparents went to missionaries and lost connection to country. The traumatic removal of children from their homes during the Stolen Generations has had a complex and tragic impact on Aboriginal cultural identity.
Giddens (1991) wrote that in late modern society, individuals have a freewill to craft their own identities. Religious institutions and cultural groups are less influential than in they were in previous eras. This is illustrated by students’ families who may have chosen not to practice Aboriginal culture.

These students’ cultural identity is further complicated by adolescence. Adolescence is a period of identity crisis (Erikson, 1968; Marcia, 1980) where young people ask critical questions about themselves. This period is often characterized with young people separating from family and associating more with peers (Erikson, 1968). “The identity crisis of adolescence is resolved by reconciling the identities imposed upon oneself by one’s family and society with one’s need to assert control and seek out an identity that brings one satisfaction, feelings of industry, and competence” (French, et al., 2006, p. 1).

A few students revealed that their parents and grandparents neither spoke about their culture nor shared any stories.

_Nana does not share any stories. I would like to hear a lot of Dreamtime stories especially. She probably does not tell stories cause she is too old or maybe her Nanas did not tell her any stories._ HE, School Quandong

Gilbert, Hipkins, & Cooper (2005) emphasize the importance of story in all cultures. Origin stories (The Dreaming for Aboriginal people), describe where people come from, how they are related and how they remain connected. It is important that young children are told stories and can tell stories about themselves (Gilbert, et al., 2005). Stories are part of identity formation. Stories provide context in which individuals develop a sense of self. Stories can shape identities, realities and the imaginative construction of future worlds.

A number of students reported moving to Hedland and being far from their family or not living with their Aboriginal parent.

_Well I don’t live with my dad and my dad is Aboriginal, he lives down in Perth and my mum, she is not Aboriginal so we don’t really do much with all that sort of stuff._ HL, School Quandong
I would like to give it [Aboriginal culture] a go. I actually have not been to any traditional ceremonies with my relatives because I have not seen them in so long and every time I do get to see them I spend a short amount of time with them before I have to come back here. HT, School Quandong

Most of our family is all in Darwin. We kinda split up in different places so we don’t really see each other and most of [the] family does not like dancing. FS, School Quandong

A number of scholars have conducted studies exploring characteristics of Aboriginal students’ and their education outcomes. Focus has mainly been on the concept of self (Bodkin-Andrews, O'Rourke, & Craven, 2010; Purdie & McCrindle, 2004; Yeung, Craven, & Ali, 2013). Self concept involves student perceptions of themselves and their academic work (Wigfield & Karpathian, 1991). Quantitative techniques to measure self concept between groups, for example Indigenous and non-Indigenous, have measured: family, self-acceptance, school, academic achievement, peer, and career (Purdie & McCrindle, 2004). Purdie et al (2000, p. 46) recommend that in order for Aboriginal students to achieve successful educational outcomes, a positive-self identity “both as an Indigenous Australian and as a competent and confident student within the school system” needs to be supported both in home and school contexts.

A study looking at Indigenous mothers’ aspirations for their children interviewed 14 mothers in Perth, Western Australia (Lette, D'Espaignet, Slack-Smith, Hunt, & Nannup, 2009). In that study all the mothers wanted to share indigenous knowledge and history with their children. However the quotes from four mothers were not included in the publication because these mothers “focused on traditional learning such as connectedness with Indigenous family, history and culture, and did not speak of mainstream education” (Lette, et al., 2009, p. 66). The authors speculated that mothers with negative school experience considered formal education a threat to maintaining Indigenous identities and therefore kept their children within the traditional system as much as possible because they did not see any benefits of the formal education process. Lette et al’s (2009) study highlights Aboriginal parents’ desire for school to recognize and value Aboriginal students and for schools to have programs that recognize Aboriginality.
Aboriginal students made little reference to contemporary Aboriginal culture. Students often referred to Aboriginal culture as back in the days, while hunting, cooking and camping were referred to as current practices. When talking about traditional Aboriginal dancing and music, students would use the pronoun “they” suggesting this was something others did but they did not see themselves as being part of. In reference to a local Aboriginal festival and NAIDOC week (a week that celebrates Aboriginal and Torres Strait Islander history, culture and achievement), one student said

At NAIDOC week, they do all, like they all come together, talk, activities and talk about their lives and all that. HL, School Quandong

Although we did not conduct Multigroup Ethnic Identity Measure Exploration (Phinney, 1992), the above quotes illustrate that some students experienced limited participation in traditional activities and although most had a sense of belonging and affirmation, few reported actively exploring their identity. Exploration is an important aspect of ethnic identity development (French, et al., 2006; Phinney, 1989). Typically, in order for an individual to reach an achieved identity, they should go through a process of exploration. Our filmmaking project provided adolescents an opportunity for exploration. The identities that students in our study present are not fixed. Although it can be considered a three stage process, ethnic identity development is iterative and occurs gradually through adolescence and adulthood (French, et al., 2006).

Language and cultural identity are closely related. In Maori education, students attest to the importance of speaking the language and their cultural identity (Kidman, Abrams, & McRae, 2011). One of the Follow the Dream students commented she was envious when she heard an Aboriginal boy at the primary school fluently speaking an Aboriginal language.

Aboriginal identity is closely related to kinship ties with many people originally coming from close-knit rural communities. Kinship ties remain the dominant mode of identity and social relationships for Aboriginal people in urban centres (Yamanouchi, 2010). Pan-Aboriginality is the notion that all Aboriginal people are the same (Purdie, et al., 2000). Pan-Aboriginality on the one hand can be considered a historically constructed concept that dates back to European colonizers and the policies and practices that were enacted. On the other hand Pan-Aboriginality can be considered a creation of
organizations, for example Aboriginal health services, sports teams and school programs. Through these organizations, Aboriginal people in urban centres who do not identify with kinship lines can create relationships. Yamanouchi writes that organizations provide a sense of belonging to Aboriginal people in the absence of kinship ties (Yamanouchi, 2010). In his study of Aboriginal people in Sydney, he discusses the tensions, conflicts, overlap and contrast of Aboriginality in an urban environment where kinships and other means of identifying Aboriginality are questioned and negotiated. This is similar to the Aboriginal students in this Follow the Dream program who come to School Quandong from diverse language groups and communities. We recognise that students in this program are young and less mature. A sense of Aboriginality rather than kinship ties is a prerequisite for membership in the Follow the Dream program.

At School Rainbow, a multicultural school in the capital city of Perth, there was tension between Aboriginal students and students from other cultures. The students from non-Aboriginal backgrounds acknowledged the tragic Aboriginal history but felt school cultural programs should be inclusive of other cultures.

_They should let us all do something, like all Africans do something while Aboriginal kids are going out, the Australians do something..._ PB, School Rainbow

_I feel that what happened in the past with Aboriginal and Indigenous people was bad but now they only have things for Aboriginal people. So they really don’t do anything for the others like the Africans, the Indians, the Serbian people. There are a few Serbians, all these others cultures. They don’t do anything with them. But they’ve got specific things they do with Aboriginal people so that’s something I feel strongly about. If they going to have something they may as well have everything else._ PN, School Rainbow

These comments illustrate the cultural complexity of Australia where indigenous issues and multicultural policy are treated separately (Tavan, 2006). This has been discussed in Chapter 3 in light of Australia’s national identity.
5.6 Conclusions

In this study we found that filmmaking and crafting stories of science and culture created opportunities for students to access, imagine, role play and express scientific identities that relate to their everyday lives. Wongani’s scientific identity was nurtured by a teacher whose lessons demonstrated science in his everyday life. Mickey on the other hand felt stifled in science class, as there few opportunities for him to creatively express himself; instead he preferred the dance club. At the dance club Mickey took on central and valued roles that aligned with his creative self. Some Aboriginal students were disconnected from their Aboriginal cultural identity. We suggest that using the framework of filmmaking about science and culture together with scaffolding and guidance from Aboriginal mentors, the Aboriginal students in the Follow the Dream program can begin to address some of the gaps in knowledge they experience. Filmmaking about science and culture provided opportunities for students from any cultural background to try on scientific identities and explore their cultural identities.
6 Conclusions and recommendations

This study sought to examine the connections and comparisons students make between scientific and cultural knowledge, whether and to what effect student-generated films about science and culture bridge home and school worlds and what filmmaking reveals about students’ identities. The main findings of this study are that students identified common ground between scientific knowledge and cultural knowledge. However this was limited to visual and material concepts such as food, music and dance. Examples of values, attitudes and beliefs were seldom reported as common ground linking scientific and cultural knowledge.

Most students categorized technology as only related to scientific knowledge and provided tokenistic, stereotypical views of culture. Students also perceived scientific knowledge as being modern and progressive whereas cultural knowledge was seen as ancient, static and basic. However participating in the process of filmmaking encouraged students to consider culture as a dynamic, rich resource. Furthermore, making films about science and culture engaged students in researching and understanding science in personally relevant contexts. In doing so, students were able to try on scientific identities. Filmmaking gave students autonomy, legitimized non-traditional sources of knowledge and facilitated intercultural understanding. This validation of funds of knowledge was an empowering experience for students and their families. These findings highlighted the role of teachers as “cultural brokers” or “travel agents” who support students’ navigations between science at school and culture at home.

The outcomes of the activities about science and culture were students’ engagement with science learning, empowerment, trying on of scientific identities and intercultural understanding. This is significant because it addresses three important issues. Firstly, the activities used in this project address concerns in science education that school science fails to engage a wide range of students (Lyons & Quinn, 2010), students find science lessons boring and students find it difficult to picture themselves as scientists (Basu & Calabrese Barton, 2007; Lyons & Quinn, 2010; Tytler, 2007). The second issue is the increasing multicultural nature of Australia (Australian Bureau of Statistics, 2012). The third issue is the difficulty teachers perceive in incorporating indigenous
knowledge in science learning (Baynes & Austin, 2012; Phiri, 2008). The findings from both Australian and Malawian schools demonstrate that making films about science and culture can attend to problems in any country where curricula have been found to lack personal relevance to students and didactic teaching is the dominant of instruction (Dzama, et al., 2008; Goodrum, et al., 2011; Tytler, 2007).

This study is unique in researching an activity that was conducted in a multicultural context, i.e. at School Rainbow. Most other studies on intercultural science education are administered in classrooms with one main ethnic minority group (Boutte & Hill, 2006; Morrison, et al., 2008). In a multicultural context, films about science and culture supported all cultures and thus facilitated intercultural understanding.

6.1 Originality and significance

This thesis provides novel insights to the study of multicultural science education. Novel research methodologies, group meaning maps and a story box activity were developed and used to explore students’ perspectives of the connections between scientific knowledge and cultural knowledge. This research is timely as Australia is becoming increasingly multicultural (Australian Bureau of Statistics, 2012) and has implemented a national science curriculum that includes indigenous knowledge (Baynes & Austin, 2012). Furthermore, in both Australia (Baynes & Austin, 2012) and Malawi, teachers (Glasson, et al., 2010) struggle to make the connections between scientific knowledge and cultural knowledge.

The group meaning maps, story box activity and filmmaking revealed a number of findings that significantly add to the literature on multicultural science education. For example students reported topics that can be used as scaffolds, common ground, to bridge cultural knowledge and scientific knowledge. However these topics were limited to easily observable phenomena such as food and dress. Extending Aikenhead and Jegede’s (1999) notion of teachers as ‘cultural brokers’, teachers can go further to incorporate other thematic areas that bridge scientific knowledge and cultural knowledge such as value, attitudes and beliefs. It is worth noting that opportunities to engage students in discussions about culturally mediated knowledge should not be limited to formal education but can also be prompted by the use of objects in informal education spaces.
This research is also novel in that other studies of multicultural science education (Aikenhead & Ogawa, 2007; Emdin, 2010; Glasson, Frykholm, Mhango, & Phiri, 2006; Upadhyay, 2009; Calabrese & Tan, 2010) have been located in homogenous or bicultural school groups, this study offers a unique perspective from multicultural school groups in Australia and Malawi. Furthermore, this study extends funds of knowledge (Moje et al., 2004) to demonstrate how combining funds of knowledge and filmmaking can have positive impacts on empowerment and engagement of students and the promotion of intercultural understanding.

6.2 Students’ understanding of scientific and cultural knowledge

The overrepresentation of science content knowledge (facts and theories) in group meaning maps, in comparison to concepts related to values, attitudes and beliefs, is similar to findings from other studies that surveyed teachers and students and reported content heavy curricula and didactic teaching focus mainly on facts and theories and less on learning about skills and processes (Glasson, Frykholm, Mhango, & Phiri, 2006; Tytler, 2007). This is synonymous with findings from other studies that observe the nature of science is rarely taught in school (Meyer & Crawford, 2011; Tytler, 2007) even though it illustrates a number of important features of science such as limitations, creativity, bias, and uncertainty.

Students in this study identified common ground between scientific and cultural knowledge, however cultural knowledge was considered inferior to scientific knowledge. In the group meaning maps and in the science and culture story box, students characterized cultural knowledge as old and basic and science as modern and progressive. This dichotomous and naïve view of scientific and cultural knowledge possibly emanates from two conceptions: the historical dominance of western science which valorises scientific knowledge and trivialises cultural knowledge (Sen, 2012) and the popular pluralistic definition of culture which promotes stereotypical and tokenistic representations of culture (Seiler, 2013). When students hold these naive views about the distinction between scientific and cultural knowledge, the opportunity for meaningful intercultural understanding is reduced and equity and social justice may be hindered (Upadhyay, 2010).
However for those students involved in this filmmaking project, their films about science and culture paint a different picture. The films students produced demonstrated an enlightened understanding and dynamic definition of culture. Students interpreted culture as encompassing their day-to-day life experiences such as cooking, animals, plants, and their environment; through performance such as dancing, playing an instrument or sports; and history or family traditions that are passed down through generations. Those students who understood culture as contemporary and dynamic, and the relative few who then connected culture to science, were better able to perceive science in their everyday lives.

6.3 Common ground

A recurring pattern in group meaning maps, story box activity discussions and students’ films was a perception of common ground between scientific and cultural knowledge that was centred on specific visual and material themes, namely food, music, dance and the environment. This finding has several implications for scaffolding learning about the connections between scientific and cultural knowledge. These themes are common fundamental characteristics of every culture and can be presented in contemporary and traditional styles. Food has been used to engage ethnic minorities in science learning (Tsurusaki, et al., 2013) and music has been used to engage at risk youth with science (Elmesky, 2005). These themes – food, music, and dance – provide a mental bridge in which to demonstrate how scientific knowledge and cultural knowledge can co-exist in students’ everyday lives. Students who took part in this study were found to already be aware of these connections, indicating that classroom activities can build on this awareness. However, in order to avoid potential tokenism (Seiler, 2013), these themes – food, music and dance – should be incorporated holistically, respectfully, in relation to and interacting with other cultures and aspects of culture such as values and beliefs.

Notably representations of cultural values and beliefs were missing from student films and were not identified amongst the bridging themes. In group meaning maps, religion was commonly associated with cultural knowledge and also perceived as a link between scientific and cultural knowledge. However only one student from School Quandong, out of the total thirty-nine films, portrayed a story on spiritual connections. Representing connections between scientific and cultural knowledge that relate to values and belief is challenging. However, by enabling students to move from a
superficial to a more thoughtful understanding of culture, genuine intercultural consciousness may be achieved.

### 6.4 Cultural identity

Intriguing findings of this research were students reporting ambiguous conceptions of Australian national identity, Aboriginal students’ limited experiences and knowledge of Aboriginal culture, and the perception and effect of privileging Aboriginal culture in a multicultural context. For Malawian students, filmmaking was an opportunity to explore science in their day-to-day lives whilst for Australian multicultural students, but more so for Aboriginal students, filmmaking was an opportunity to validate their own culture as seen in a particular number of Aboriginal students’ films about family. This difference between the Australian and Malawian cohort may be explained by an Australian history that disparaged Aboriginal culture (Bretherton & Mellor, 2006).

There are number of reasons that explain Aboriginal students’ interest in their culture but limited cultural knowledge, foremost being the tragic Stolen Generation which has caused some families to lose their spiritual and physical connection to country (Bretherton & Mellor, 2006). The inclusion of indigenous knowledge in the science curriculum is an important opportunity for Aboriginal students as well as students from other cultures to learn about Aboriginal knowledge. However, teaching about Aboriginal knowledge must take into account the richness and diversity of Aboriginal people across Australia. It must respect and be mindful of spiritual connections and worldviews, and it must recognise modern influences on the lives of Aboriginal people. For Aboriginal students, school lessons and activities are of course not an equal substitute for the powerful experience of knowledge and stories passed down through family.

The benefits of cultural diversity and improving young peoples’ intercultural consciousness include positive effects on students’ cognitive development, leadership abilities (Astin, 1993), intellectual growth and improved academic skills (Gurin, et al., 2002) and enhanced critical thinking (Pasquarella & Blimling, 1996). In this study, although students recognized Aboriginal culture as Australian culture, they were less aware of non-Aboriginal Australian culture. This was illustrated both in students’ group meaning maps and in discussions during the story box activity where examples of
Aboriginal culture dominated. This recognition of Aboriginal culture is encouraging however in a multicultural country like Australia this poses challenges. Students from School Rainbow acknowledged and were remorseful about the tragic Aboriginal history, but commented that school programs favoured Aboriginal culture and failed to embrace cultural diversity. This tension is also reflected in a lack of a strong Australian national identity that respects Aboriginal people as the first people of Australia and is inclusive and representative of other cultures (Moran, 2011).

6.5 Student autonomy

Incorporating funds of knowledge and filmmaking in school achieved a number of goals. Filmmaking was an empowering experience that gave autonomy to students both in Malawi and Australia and validated non-traditional sources of knowledge in a school-based project. Empowerment was not limited to students; family and community members were also positively impacted as they were positioned as experts with valid knowledge of life experiences. At community screenings, families and students displayed pride in the students’ cinematic achievements. The presence of Aboriginal guardians and parents at the film screening at School Quandong is a significant outcome; for socio-historical reasons, Aboriginal parents rarely attend school functions (Lette, et al., 2009).

Filmmaking created opportunities for students to access, imagine, role play and try on scientific identities that relate to their everyday life (Lave & Wenger, 1991). This can address the commonly identified problem of students failing to picture themselves as scientists (Basu & Calabrese Barton, 2007; Lyons & Quinn, 2010; Schreiner & Sjøberg, 2007; Zimmerman & Bell, 2012) and students not given opportunities to pursue scientific areas of interest in class (Goodrum, et al., 2011). Filmmaking encouraged students’ participation, creativity and expression. Films about science and culture supported practice-linked identities through providing access to knowledge and skills, offering opportunities for students to take on central and expert roles and encouraging creativity and expression (Nasir & Hand, 2008).

6.6 The role of teachers

The role of teachers in supporting students’ understanding of science in their everyday life is illustrated through findings from the Malawian school group compared to the
Aboriginal cohort. A teacher at School Nyasa had used locally relevant examples to demonstrate scientific concepts that allowed students to make complex connections between scientific and cultural knowledge. Aboriginal students, on the other hand, experienced difficulty in making connections because they had teachers who taught mainly theoretical principles and teachers who were not able to manage classroom behaviour. This was compounded by high school teacher transience and Western Australia’s Department of Education practice of placing inexperienced teachers recently graduated from Schools of Education into rural and regional schools. Teachers should act as “cultural brokers” or “travel agents” supporting students’ navigations between different worlds (Aikenhead & Jegede, 1999). Teachers need to be supported with professional development and resources in order to fulfil this role otherwise there is risk of trivializing indigenous knowledge (Austin & Hickey, 2011). However with increasing demands on teacher time, implementation of new, content-heavy curricula, and negative attitudes towards indigenous knowledge, a meaningful holistic approach to teaching indigenous knowledge and science is often not a priority for school science departments (Baynes & Austin, 2012). Findings from this research suggest an opportunity for informal science educators to develop exhibits and activities that embrace traditional and contemporary indigenous knowledge and science.

6.7 Recommendations and future research

Three recommendations have emerged from this research. Firstly, to address beliefs about indigenous knowledge and science, students need to be supported in redefining culture as it relates to science. Secondly, to attend to the relevance of science education and students’ engagement, students should be given opportunities to practice autonomy and participate in activities that encourage use of all funds of knowledge including non-traditional ones. Thirdly, informal science educators have a role to play in supporting teachers and students in recognising and appreciating the connections between scientific and cultural knowledge.

The 2012 Australian curriculum under the strand Science as Human Endeavour has a sub-strand on the Nature and Development of Science. Although a number of comprehensive online curriculum support materials for indigenous knowledge (Living Knowledge, Primary Connections) are available, few go beyond detailed content
knowledge. It is possible to develop an integrated teaching approach connecting scientific and cultural knowledge that supports these aims:

- values-based common ground between scientific and cultural knowledge
- learning about the Nature and Development of science
- fostering links between schools, universities and industry that focus on authentic research (recommendation 3 of the Choosing Science report (Lyons & Quinn, 2010).

For example, Aboriginal knowledge of burning practices and water management has informed scientific research in areas such as environmental management (Horstman & Wightman, 2001; Russell-Smith, et al., 1997). These and a number of other studies report on partnership projects between CSIRO (Australia’s government research agency) and Aboriginal custodians on areas such as weather, climate change, and astronomy (Davies, White, Wright, Maru, & LaFlamme, 2008; Green, Billy, & Tapim, 2010; Hamacher & Norris, 2010; Prober, O'Connor, & Walsh, 2011). A learning program that combines scientific organisations, Aboriginal custodians, authentic research and inquiry may have beneficial outcomes in increasing students’ appreciation of the nature of science and scientific and cultural values. An additional benefit of a program that publicly recognises Aboriginal contributions to science, is that it may address perceptions that science “leeches off” Aboriginal culture, as has been reported in other research (Recht, 2009) and explicitly stated by one student in this study.

A pedagogical approach that could be considered in teaching that supports cultural inclusion is Contiguity Argumentation Theory (Ogunniyi, 2006). This type of argumentation that has been trialed successfully in South Africa involves discussions on the nature of science and the nature of indigenous knowledge. Contiguity Argumentation Theory encourages students and teachers to discuss viewpoints, recognize and appreciate cultural and scientific worldviews through the use of a dialogical framework that consists of claims, evidence, warrants, backings, rebuttals and qualifiers.

This research was mainly conducted in a school setting but can be adapted to informal education contexts. There exists opportunities for informal science educators to develop exhibits and activities that support teachers’ and students’ understanding of scientific knowledge and cultural knowledge. Exhibits that incorporate narratives of objects may support this goal. This is an area that warrants further research.
A limitation of this study was that students’ ancestries were not mapped to group meaning maps or story box activity. This is an area that could be investigated further to explore the extent to which knowledge is culturally mediated and how teachers, families, ancestries, popular culture and peers influence student perceptions’ of scientific knowledge and cultural knowledge.

6.8 Conclusion

This study set out to address the problem of the lack of relevance in science education to students’ lives, particularly in multicultural schools. A solution is presented in the form of a workshop where students work autonomously to create films about science and culture. This study shows that creating films allows students to engage with science and empowers them through incorporating peer, family and community funds of knowledge. This research makes an important contribution by connecting several disparate areas of research, including funds of knowledge, filmmaking and identity. Is provides insights into ways in which students can be engaged and empowered during science learning. This study highlights the need for teaching that embraces cultural diversity in schools. The filmmaking workshop is a useful and engaging tool that can be used by both teachers and outreach providers.
References


Australian Curriculum Assessment and Reporting Authority. (2012). General capabilities in the Australian Curriculum.


Department of Immigration and Citizenship. (2011). The People of Australia – Australia’s Multicultural Policy


McInerney, V. (2003). *Multiculturalism in today’s schools: have teachers’ attitudes changed over two decades?* Paper presented at the SELF Research Centre at the Annual Meeting of the Australian Association for the Research in Education Auckland, New Zealand


Stances identified from an interview study. *Science Education, 95*(6), 1000-1025.


Teo, T. W. (2013). Different perspectives of cultural mediation: implications for the research design on studies examining its effect on students' cognition. *Cultural Studies of Science Education, 8*(2), 295-305.


UN Habitat. (2011). Malawi: MZUZU urban PROFILE.


Appendix 1 Images for the science and culture story box activity

1. Coartem
Coartem is antimalarial drug that has been developed from the artemether/lumefantrine. Arthemether is isolated from the Chinese antimalarial plant, Artemisia annua, Chinese sweet wormwood.

2. Guitar
Guitars and music are important part of many cultures; e.g. ukulele features prominently in Hawaiian music. Scientific knowledge helps us to understand how sound is generated from an acoustic guitar through vibrations, the soundboard and the sound hole.

3. Winnowing basket
Science: fractals in the pattern and designing and the weaving. The method to determine the best reeds to use for the basket and how the reeds are dyed.
Winnowing: a process through which lighter substances are removed by the force of wind. When the mixture is thrown from a height, the wind takes away the lighter substances from the heavier substances.

4. Wellcome Image awards
Zebrafish retina – science and art. This image was created using double in situ hybridisation, a staining technique that identifies spatial expression of gene products. The zebrafish is widely used as a model organism for research into vertebrate development.

5. Aztec calendar @ GDC
The Aztecs used two different calendars, one measured time, while the other was used to fix religious festivals. The time-measuring calendar was used to fix the best time for planting crops, while the religious calendar told when to consult the gods.

6. Bush tucker @ GDC
Macrozamia riedlei and Macrozamia fraseri - Zamia (Jeeriji). The nuts are poisonous if eaten raw or with little preparation. Nuts are buried, thoroughly washed and leached, and then roasted before eating. The nuts from palm have been successfully utilised as food by Indigenous Australians - however eaten raw by European explorers incurred poisoning.
7. Is a football or bucky ball?
A buckyball is a soccer-ball shaped molecule containing 60 atoms of carbon. The 60 atoms are bonded together to make 12 pentagons and 20 hexagons. The GDC cosmology gallery roof is the shape of a bucky ball.

Consider sport as culture. Also the study of sports through sports science - which helps us design materials for the ball and understand the forces that occur during a banana kick.

8. Compass/GPS
The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.

Consider how did people navigate before GPS?

9. Mobile phone
How did people communicate over long distances before mobile phones?

10. Beaker
A beaker is a simple container for stirring, mixing and heating liquids commonly used in many laboratories.

11. The Dreaming
The Dreaming for Australian Indigenous people (sometimes referred to as the Dreamtime or Dreamtimes) is when the Ancestral Beings moved across the land and created life and significant geographic features. This painting tells us a story and has a number of star constellations.
12. Wedding dress
A wedding dress or wedding gown is the clothing worn by a bride during a wedding ceremony. Colour, style and ceremonial importance of the gown can depend on the religion and culture of the wedding participants.

13. Nike shoes
Nike Air Max provides the ultimate in impact protection — reducing shock and distributing pressure — to provide you with absolute comfort and stability. The Nike tick represents the wing of the Greek Goddess of victory, Nike. A lot of sports science goes into designing Nike shoes. Nike is part of popular culture.

14. Lightning
There are many cultural interpretations (Greek – Zeus, Nigerian – Ram and Sheep) as well as scientific explanations. All cultures seek to understand their world.
“When the hummingbird comes, it is time for the seed to be planted. The hummingbird never lies.”

15. Zuni tribe phrase
An intimate connection with the land and keen observations is important for the survival of many cultures.
Appendix 2 Connecting science and culture lesson plan

Purpose:
To provide an opportunity to explore connections between cultural knowledge (Aboriginal knowledge and other Indigenous knowledges) and scientific knowledge.

Participant outcomes:
- Participants will recognize and value the multitude of connections and relationships between Aboriginal knowledge, other Indigenous knowledge and scientific knowledge.
- Participants demonstrate a respect for and valuing of how different cultures have contributed to science and how science is also embedded within cultural knowledge.

Background points:
- Students bring different worldviews, histories and cultures in the classroom that are often neglected in learning.
- Classrooms in Australia are becoming extremely diverse with Anglo-Australian students, Aboriginal students and students from other cultures.
- This activity, mainly the student centred discussion and scaffolding questions posed by the facilitator, is focused on creating meaning and understanding. By clarifying meaning of concepts like science, cultural knowledge (Aboriginal and Indigenous knowledge), students can begin to access a deeper meaning and make links between these concepts and their experiences.

Suggestions for a Gravity Discovery Centre focus:
(Gravity Discovery Centre is a science centre 70km from Perth, Western Australia’s capital city)
- Use images of exhibits or from the Timeline of the Universe.
- Break students in to groups and ask them to go on a “treasure hunt” to find one example of scientific knowledge, cultural knowledge and one that represents both scientific and cultural knowledge.
- Include a viewing of John Goldsmith’s video – Kandimalal and a discussion on different ways of knowing.
- Focus discussions on images and issues related to Astronomy, Astrology, Creation Stories, The Dreaming – how stars are used in different cultures for navigation, farming, hunting.

Connections to Curriculum:
- Fulfils general capabilities: intercultural understanding across the curriculum, critical and creative thinking and personal and social capability.
- Strand: Nature and development of science
- Curriculum element: Important contributions to the advancement of science have been made by people from a range of cultures (ACSH082).

Year level:
Years 7-9

Duration:
45 minutes

**Resources required:**
- butcher’s paper
- images
- textas
- whiteboard
- whiteboard markers
- blue-tac

**Classroom set up:**
- students in groups of 4 sitting around tables.

**Preparation:**
- for each group: a texta, butcher’s paper, envelope with all the small images (15) and a few larger images for whole group discussion.

**Instructions:**

1. **Introduction (5 mins):** Explain to students that they going to explore concepts. You can ask students how they would define the term concept and provide examples of concepts.

   **Concept definition:**
   - A general idea derived or inferred from specific instances or occurrences.
   - Something formed in the mind; a thought or notion.
   - A scheme; a plan

   Have they ever considered concepts like knowledge, love, culture. Concepts are contestable. That means there are no clear definitions about them. The study of concepts in fields like philosophy can be exciting, be confusing, create a sense of wonder or be controversial. Studying concepts can help us reach a deeper understanding about them.

   This activity is aimed at revealing concepts about scientific and cultural knowledge and using objects or processes to discuss their connections. Science and culture are two big concepts which despite being around for many years and being very important, are still incompletely understood.

   The connections between science and cultural or Indigenous knowledge will be explored using a group meaning map (similar to mind map – but we as a group can assign whatever meaning we want to these two concepts – there are no right or wrong answers). Then working in groups, students will discuss the scientific and or cultural associations of different objects or processes. Note that cultural/Indigenous knowledge relates to knowledge from different cultures – Aboriginal, Asian, African, and European.

   One rule: everything is valid! Students must respect and listen to someone else’s point of view. This is not a debate. The aim is to work together to reach a consensus.

2. **Example group meaning map on Books and Movies (5 mins):** if students have not done mind maps before, you can demonstrate a connecting group meaning map
with books and movies on the white board where you ask students to provide examples and the facilitator writes them down.

Example Books and Movies group meaning map

3. Science and cultural knowledge, group meaning map (10 minutes). Draw in one circle scientific knowledge and then in another circle cultural knowledge. The objective is to add as many ideas as possible and find ways to connect the two concepts.

You can either do this as whole group activity or ask students to do this in groups on their own. Keep the group meaning map on the board or ask groups to hold onto their group meaning map, as you/they will refer to it at the end of the lesson.

Instructions for map

- Use just key words phrases, or wherever possible images.
- Start from the centre of the page and work out.
- Create sub-centres for sub-themes.
- Don't get stuck in one area. If you dry up in one area go to another branch.
- Put ideas down as they occur, wherever they fit. Don't judge or hold back.
- Be creative. Creativity aids memory.
- Get involved. Have fun.
- There is no right or wrong.

4. Connecting science and culture images (10 mins). Draw a Venn diagram on the board.
Hand out textas, butcher’s paper and envelopes with 15 images for each group. Make sure that each group has at least 1-2 of the bigger images and blue-tac.

Instruct the group to draw a similar diagram on the butcher’s paper.
- with the small images they need to place them on the Venn diagram. They need to reach a group consensus on whether the object or process in the image is scientific knowledge, cultural knowledge or both.
- with the larger images, the group should choose someone in the group. During the classroom discussion, this person will come up to the whiteboard and place the image in the Venn Diagram on the whiteboard using blue-tack in one of the domains and tell the class the justification for choosing that domain.

5. Classroom discussion (10 mins). Go around each group asking them to send their representative to place their image on the white board using blue-tac. After the person has explained their reasoning. Open it up to classroom discussion.

Questions that can be asked to encourage critical thinking:
- Does everyone agree with this? Why?
- Is that a good enough reason?
- What are some other possible explanations?
- How do you know?
- Is there anyway that we could be wrong?
- What does that tell us?
- How does that fit with X?
- Do those two ideas agree?
- How is that different from X?
- Can you think of any other examples?
- How else could we think about that?
- What would be a different view?

Questions related to scientific and cultural knowledge:
- When we try to find a causal explanation for something, are we doing science? (can be used for Lightning image or The Dreaming)
- If a subject area develops theories to explain things, is it a science? (can be used for Lightning image or The Dreaming)
- What’s the difference between explaining the seasons by talking about the gods who get tired at winter or by talking about the planets revolving around the sun? (can be used for Zuni tribe phrase or Aztec calendar)
- What makes an explanation scientific?
- Are there other ways to get knowledge besides science?
- Is science the best way?
- Should we trust science more than cultural knowledge?
- In what ways has cultural knowledge contributed to science? (can be used for medicine image)
- Is there a distinction between cultural knowledge and culture? (can be used for football and guitar)
- What is the difference between popular culture and Indigenous culture? (can be used for Nikes)

6. Wrap up (5 mins) Refer back to the Group meaning map, based on the activity are there more links that can be added to the map.

Conclusion: Why connect scientific knowledge and cultural knowledge? Both systems are valuable ways of knowing and understanding, they learn from each other and help people make sense of their world.

The multiple ways scientific and cultural knowledge connect:
- both are bodies of knowledge that are stable but are subject to modification.
- both have grown from people being inquisitive, persevering, recognize patterns, observing their natural surroundings, inferring and making predictions.
- science can be used to understand some of the tools developed from cultural knowledge e.g. winnowing basket.
- Scientific knowledge and cultural knowledge both have their beliefs, values and norms.
- Cultural knowledge and technologies can be explained in conventional science terms. e.g. use of medicines.
- A conventional science link can be made to cultural knowledge, even though the underlying principles are different. For example staying away from lightning.
- Cultural knowledge is informing science in areas like medicine, agriculture and the environment.

During this activity, students have thought critically and have respected the views of others.
### Appendix 3 Timetables for film training

**School Quandong**

<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Venue</th>
<th>Activity</th>
<th>Time required</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wk 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 8th</td>
<td>Monday</td>
<td>GPFF site with Muza</td>
<td>Introduction, ice breakers, story elements, sample digital story</td>
<td>40 mins</td>
</tr>
<tr>
<td></td>
<td>Day 1</td>
<td></td>
<td>Practise filming</td>
<td>1hr</td>
</tr>
<tr>
<td>August 9th</td>
<td>Tuesday</td>
<td>GPFF site with Muza</td>
<td>Practise editing</td>
<td>2hrs</td>
</tr>
<tr>
<td></td>
<td>Day 2</td>
<td></td>
<td>Developing the story - pre personal meaning maps (PMMs), connecting scientific and cultural knowledge story box, post PMMs</td>
<td></td>
</tr>
<tr>
<td>August 10th</td>
<td>Wednesday</td>
<td>GPFF site with Muza</td>
<td>Check in and review of story elements, Story circle</td>
<td>2hrs</td>
</tr>
<tr>
<td></td>
<td>Day 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 11th</td>
<td>Thursday</td>
<td>GPFF site with Muza</td>
<td>Research and storyboarding, scripts, call sheets, recceis</td>
<td>2hrs</td>
</tr>
<tr>
<td></td>
<td>Day 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Wk 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 16th</td>
<td>Tuesday</td>
<td>Independent</td>
<td>Filming</td>
<td>2hrs</td>
</tr>
<tr>
<td></td>
<td>Day 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 18th</td>
<td>Thursday</td>
<td>Independent</td>
<td>Filming</td>
<td>2hrs</td>
</tr>
<tr>
<td></td>
<td>Day 6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Wk 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 22nd</td>
<td>Monday</td>
<td>GPFF site with Muza</td>
<td>Editing</td>
<td>2hrs</td>
</tr>
<tr>
<td></td>
<td>Day 7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 23rd</td>
<td>Tuesday</td>
<td>GPFF site with Muza</td>
<td>Editing</td>
<td>2hrs</td>
</tr>
<tr>
<td></td>
<td>Day 8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 24th</td>
<td>Wednesday</td>
<td>Venue to be confirmed - evening</td>
<td>Community screening (family and friends invited)</td>
<td>2hrs</td>
</tr>
<tr>
<td></td>
<td>Day 9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 25th</td>
<td>Thursday</td>
<td>GPFF site with Muza</td>
<td>Focus group discussion and interviews</td>
<td>2hrs</td>
</tr>
<tr>
<td></td>
<td>Day 10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August 26th</td>
<td>Friday</td>
<td>GPFF site or school with Muza</td>
<td>Interviews</td>
<td>8 hours (30 minute each student)</td>
</tr>
<tr>
<td></td>
<td>Day 11</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## School Rainbow

<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Venue</th>
<th>Activity</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wk 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Day 1  – Mon</td>
<td>Year 7</td>
<td>Introduction, ice breakers, Developing the story - connecting scientific and cultural knowledge story box</td>
<td>10:50-12:20</td>
</tr>
<tr>
<td></td>
<td>31st Oct</td>
<td>classroom</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Day 2  – Tues</td>
<td>Year 7</td>
<td>Framing and audio, Practise filming</td>
<td>1300 - 1430</td>
</tr>
<tr>
<td></td>
<td>1st Nov</td>
<td>classroom</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Day 3  – Thurs</td>
<td>ICT lab</td>
<td>Practise editing, developing the story</td>
<td>1300 - 1415</td>
</tr>
<tr>
<td></td>
<td>3rd Nov</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Day 4  – Fri</td>
<td>Year 7</td>
<td>Story elements, Story circle, Research and storyboarding, scripts</td>
<td>1300 - 1500</td>
</tr>
<tr>
<td></td>
<td>4th Nov</td>
<td>classroom</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Independent filming</td>
<td>Independent filming possible over the weekend with permission</td>
<td></td>
</tr>
<tr>
<td>Wk 2</td>
<td>Day 5  – Mon</td>
<td>Year 7</td>
<td>Filming</td>
<td>1050 - 1220</td>
</tr>
<tr>
<td></td>
<td>7th Nov</td>
<td>classroom</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Day 6  – Tues</td>
<td>Year 7</td>
<td>Filming</td>
<td>1300 - 1430</td>
</tr>
<tr>
<td></td>
<td>8th Nov</td>
<td>classroom</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Day 7  – Wed</td>
<td>ICT lab</td>
<td>Editing</td>
<td>1300 - 1500</td>
</tr>
<tr>
<td></td>
<td>9th Nov</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Day 8  – Thurs</td>
<td>ICT lab</td>
<td>Editing</td>
<td>0850 - 1030</td>
</tr>
<tr>
<td></td>
<td>10th Nov</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wk 3</td>
<td>Day 10 – Mon</td>
<td>ICT lab</td>
<td>Final Edit</td>
<td>1050 - 1220</td>
</tr>
<tr>
<td></td>
<td>14th Nov</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Day 11 – Tues</td>
<td>Venue TBC (school hall)</td>
<td>Community screening (family and friends invited)</td>
<td>1300 - 1430</td>
</tr>
<tr>
<td></td>
<td>15th Nov</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Day 12 – Wed</td>
<td>Year 7</td>
<td>Focus group discussion and interviews</td>
<td>8 hours (15 mins/student)</td>
</tr>
<tr>
<td></td>
<td>16th Nov</td>
<td>classroom and class periods</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Personal meaning maps (PMMs) – GDC 17th October
<table>
<thead>
<tr>
<th>Date</th>
<th>Day</th>
<th>Venue</th>
<th>Activity</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wk 1</td>
<td>Day 1 – Mon 19th Sept</td>
<td>ICT lab</td>
<td>Introduction, ice breakers, story elements, sample digital story</td>
<td>8-9 (ICT)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Practise filming</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Day 2 - Tues 20th Sept</td>
<td>ICT lab</td>
<td>Practise editing</td>
<td>3-4 (History)</td>
</tr>
<tr>
<td></td>
<td>Day 3 - Wed 21st Sept</td>
<td>ICT lab</td>
<td>Developing the story - Personal meaning maps (PMMs), connecting</td>
<td>1-2 (ICT)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>scientific and cultural knowledge story box</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Day 4 - Thurs 22nd Sept</td>
<td>Room 2</td>
<td>Story elements, Story circle, Research and storyboarding, scripts</td>
<td>8-9 (PSHE)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Independent filming</td>
<td></td>
</tr>
<tr>
<td>Wk 2</td>
<td>Day 5 – Mon 26th Sept</td>
<td>ICT lab</td>
<td>Filming</td>
<td>8-9 (ICT)</td>
</tr>
<tr>
<td></td>
<td>Day 6 – Tues 27th Sept</td>
<td>ICT lab</td>
<td>Filming</td>
<td>3-4 (History)</td>
</tr>
<tr>
<td></td>
<td>Day 7 – Wed 28th Sept</td>
<td>ICT lab</td>
<td>Editing</td>
<td>1-2 (ICT)</td>
</tr>
<tr>
<td></td>
<td>Day 8 – Thurs 29th Sept</td>
<td>Room 2</td>
<td>Editing</td>
<td>8-9 (PSHE)</td>
</tr>
<tr>
<td>Wk 3</td>
<td>Day 10 – Mon 3rd Oct</td>
<td>ICT lab</td>
<td>Final Edit</td>
<td>8-9 (ICT)</td>
</tr>
<tr>
<td></td>
<td>Day 11 – Tues 4th Oct</td>
<td>Venue TBC</td>
<td>Community screening (family and friends invited)</td>
<td>1hr 30 mins in the evening</td>
</tr>
<tr>
<td></td>
<td>Day 12 – Wed 5th Oct</td>
<td>ICT lab and class periods</td>
<td>Focus group discussion and interviews</td>
<td>8 hours (15 mins/student)</td>
</tr>
</tbody>
</table>