BRIDGING CULTURES IN SCIENCE EDUCATION: LEVERAGING LESSON STUDY APPROACH FOR INDIGENOUS KNOWLEDGE INTEGRATION IN A TOWNSHIP SCHOOL

A thesis submitted in fulfilment of the requirement for the degree of

DOCTOR OF PHILOSOPHY

At

RHODES UNIVERSITY

By

XOLANI JUSTICE MAYANA

Supervisor: **Prof. Kenneth Mlungisi Ngcoza**

Co-Supervisors: **Mrs. Joyce Sewry**

Prof. Kensuke Chikamori

February 2024

DECLARATION

I **Xolani Justice Mayana** (92M2833) declare that this thesis is my original work and has not been submitted in its entirety or in part for examination for a degree to any other university or education institution. Any information that has been obtained from other scholars has been acknowledged by citation and included in the references list.

February 2024

Signature **Date**

ACKNOWLEDGEMENTS

I grew up at a time when someone particularly an adult offered you something, you would receive it with both hands and say thank you. This was a way of showing your appreciation and respect. My mother used to say '*Mbi umntu ongenambulelo mntwanam*' which literally means 'Bad is a person who is ungrateful'. Based on this upbringing and teachings, I would like to thank everyone who contributed to the success of this study in one way or another.

First and foremost, I give honour and glory to God Almighty for His unmerited favour and love, and for showering me with abundance of blessings throughout my study until I completed this project. I thank you, Lord for granting me wisdom, understanding and strength to see this project possible. Lord, I praise You!

Secondly, my appreciation goes to my family. To my lovely wife, my better half Brenda, Bri I appreciate your support my love not only in this project but in our ministry as well. To our sons Abo and Khanya who have turned out to be such fine young men and are now my friends, thank you for everything guys. Thank you for allowing me to study further and for encouraging me to keep up the good fight. Most of all thank you for your prayers and love.

I would also like to express my sincere gratitude to my supervisor, Professor Kenneth Mlungisi Ngcoza (Gxarha, his clan name), for providing guidance, support and motivation throughout this journey. In your special way Gxarha, you managed to inspire me to go on, especially when I wanted to give up. For instance, you would ask: *"How is your groundbreaking thesis shaping up Mchirh'omhle?"* And I asked myself, how could it be groundbreaking when there is no thesis to begin with? Or your magic phrase: *"Wow Cirha! A star is always a star"* kept me going and gave me strength when I needed it the most. The Bible says words have a creative power. Indeed, I experienced that creative power through your kind words Gxarha, and I thank God for you. May the Almighty God bless you; may He keep you and make His face shine on you and shower you and your family with an overflow of blessings.

To my co-supervisors, Mrs Joyce Sewry and Prof Kensuke Chikamori, thank you for your support. Prof Chikamori thank you for the articles on Lesson Studies and for organising a critical friend to facilitate a workshop for us on the Lesson Study approach. Mrs Sewry thank

you for taking your time and for arranging such insightful hands-on practical activities for our PLC. Your contribution to this study is invaluable.

My appreciation goes to my critical friends for facilitating such informative workshops (Virtual and in-person). Thank you for taking your time and for using your resources and help capacitate our science teachers to become better teachers. Ndlovu, thank you for going an extra mile my brother and motivate our teachers and for availing your critical eye which helped to improve the quality of this project. God bless you all.

A special thank you goes to all the participants in this study. *Okokuqala ndibulela kuni bazali (IKCS) ngokuzidina, ngokuzixhamla kangaka. Ndiswele imilomo eliwaka, wanga uThixo anganisikelela. Makube chosi kube licamagu.* Secondly, a big thank you to my colluegues in our PLC, if it were not for your sacrifices, your commitment, and your dedication this project could not have materialised. Thank you for attending those afternoon meetings, those workshops and for sharing your powerful ideas. Thank you very much for your reflections, your voices have helped me to be reflexive in this study. You were such an incredible team, and it was an honour to work with you.

I would like to thank Tulz for taking pictures and videos and for helping me type some of my transcribed notes. I appreciate your help, blessings to you.

A special thank you to Madiba for assisting with IT skills when needed the most.

A big thank goes to Nikki for professionally editing this thesis.

To my family at Rhodes, BEd Honours and Masters scholars, thank you for your contributions and insightful ideas during our contact sessions. That's Ubuntu!

Kuni nonke ndibamba ngazo zozibini, ngokwenene umntu ngumntu ngabantu. (To you all I am grateful, truly no man is an island)

God bless you all.

DEDICATION

This thesis is dedicated to my late dear mother Kholiswa Nothandekile Mayana who breastfed me with Ubuntu. Ndiyabulela MamSukwini ngengqeqesho yakho, ngemfundiso zakho nangemithandazo yakho, ndiyakholwa uncumile apho ukhoyo (Thank you MamSukwini for raising me, for instilling discipline in me, for your teachings and for your prayers; I am sure you are looking down on us with a smile). To God be the glory for answering your prayers. Indeed, you were an Indigenous Knowledge Custodian. Rest in peace Cwama and rise in eternal glory. I will see you in glory mama.

ABSTRACT

The South African Curriculum Assessment and Policy Statement (CAPS) encourages science teachers to use culturally responsive pedagogies in their teaching. This should be done by integrating Indigenous Knowledge (IK) in science teaching to make it accessible and relevant to learners. However, the policy falls short of giving clear details on how this ought to be done. For instance, the school textbooks hardly contain any IK and there are few or no readily available teaching resources either. To complicate matters, many science teachers have not been trained on how to integrate IK into science teaching. As a result, most of them do not integrate any IK during their science lessons. It is against this backdrop that this study aimed to leverage the use of a Lesson Study approach when working *with* science teachers on how to integrate IK to mediate learning of the topics of waves and sound and redox reactions in a township school.

Underpinned by the indigenous research and transformative paradigms, a qualitative case study approach in a form of participatory action research was adopted. Six science teachers from a township school, five Indigenous Knowledge Custodians[1] (IKCs), one critical friend (isiXhosa and English teacher from the same school) and three university lecturers and a school principal from Zambia who conducted various workshops, and I were the participants in this study. Qualitative data was generated using interviews (semi-structured and stimulated recall interviews), document analysis, workshop discussions, observations (participatory and classroom observations) and journal reflections. Vygotsky's sociocultural theory, Shulman's pedagogical content knowledge, specifically Topic-specific Pedagogical Content Knowledge (TSPCK) and Ogunniyi's Contiguity Argumentation Theory (CAT) were used as complementary theoretical frameworks. A thematic approach to data analysis was employed to come up with sub-themes and themes.

The main findings of the study revealed that through collaboration with Indigenous Knowledge Custodians and tapping into their cultural heritage the integration of IK into science lessons was possible. Thus, this study showed that leveraging the use of a Lesson Study approach when

[1]Similarly to Mutanho (2021), IKCs refer to the community members who are the custodians of the cultural heritage.

working *with* science teachers on how to integrate IK to mediate learning of the topics of waves and sound and redox reactions in a township school, shifted the science teachers' Zone of Proximal Development and Pedagogical Content Knowledge positively. Also, this study revealed that the integration of IK promotes learner talk or argumentation. Moreover, the use of isiXhosa our home language proved to be an invaluable cultural tool for effective communication in this study.

The study thus recommends that transformational professional learning communities (PLCs) be established in township schools and that teachers should work in collaboration with IKCs to learn about IK which could be integrated into other science topics. Furthermore, the study recommends that teachers should be trained in document analysis and how to use the TSPCK components to unpack the curriculum. This might help the teachers to understand the curriculum needs better, plan better, and hopefully teach better. Thus, the contention of this study is that teacher preparedness is inextricably linked to learner achievement.

Keywords: Sciences, waves and sound, redox reactions, Indigenous Knowledge, Lesson Study approach, participatory action research, professional learning community, sociocultural theory, topic-specific pedagogical content knowledge

TABLE OF CONTENTS

DECLARATION ..... **ii**

ACKNOWLEDGEMENTS ..... **iii**

DEDICATION ..... **v**

ABSTRACT ..... **vi**

LIST OF FIGURES ..... **xv**

LIST OF TABLES ..... **xvii**

LIST OF ABBREVIATIONS AND/OR ACRONYMS ..... **xviii**

CHAPTER ONE: SITUATING THE STUDY **1**

1.1 Introduction 1

1.2 Context of The Study 2

1.3 Who Am I In This Study? 4

1.4 My Positionality and Reflexivity 10

1.5 Statement of The Problem 12

1.6 Purpose and Significance of the Study 14

1.7 Research Goal and Questions 15

1.8 Theoretical and Analytical Frameworks 15

1.9 Definition of Key Concepts 17

1.10 Thesis Outline 18

1.11 Chapter Summary 20

CHAPTER TWO: LITERATURE SYNTHESIS **22**

2.1 Introduction 22

2.2 Waves and Sound in the Curriculum 22

2.3 Redox Reactions in the Curriculum 24

2.4 Prior Everyday Knowledge 25

2.5 The Nature of Science and the Nature of Indigenous Knowledge 25

2.6 What is Indigenous Knowledge? 27

2.7 Community Elders and Storytelling 29
2.8 The Role of IK in Science Teaching 30
2.9 Teachers' Perspectives on the Integration of IK into Science 32
2.10 Hands-On Practical Activities and Visualisation 33
2.11 Professional Learning Communities 33
2.12 Chapter Summary 37
CHAPTER THREE: THEORETICAL FRAMEWORKS 38
3.1 Introduction 38
3.2 Vygotsky's Sociocultural Theory 38
3.2.1 Mediation of learning 39
3.2.2 Culture and language 40
3.2.3 Social interactions 40
3.2.4 Zone of proximal development 41
3.3 Pedagogical Content Knowledge 42
3.3.1 Topic-specific pedagogical content knowledge 43
3.3.2 The revised consensus model 44
3.4 Contiguity Argumentation Theory 47
3.5 Chapter Summary 49
CHAPTER FOUR: RESEARCH METHODOLOGY 50
4.1 Introduction 50
4.2 Research Paradigms 50
4.2.1 Indigenous research paradigm 51
4.2.2 Transformative paradigm 53
4.2.2.1 Epistemology in the transformative paradigm 53
4.2.2.2 Ontology in the transformative paradigm 54
4.2.2.3 Axiology in the transformative paradigm 54
4.2.2.4 Methodology in the transformative paradigm 55
4.3 Research Design 55

4.3.1 Lesson study approach 57
4.3.2 Participatory action research approach 58
4.4 Research Goal and Research Questions 59
4.5 Research Site and Selection of Participants 60
4.6 Data-Gathering Methods: The Research Process 64
4.6.1 Focus group discussions - sharing circles 67
4.6.2 Pre-intervention workshops 70
4.6.2.1 Orientation workshop 70
4.6.2.2 Workshop on reflections 71
4.6.2.3 Workshops on lesson studies 71
4.6.2.4 Workshop on document analysis 72
4.6.2.5 Workshop on co-development of exemplar lessons 73
4.6.3 Document analysis 73
4.6.4 Observations 74
4.6.4.1 Pre-intervention observations 74
4.6.4.2 Participatory observation 75
4.6.4.3 Lesson observations (post-2 classroom observations) 76
4.6.5 Stimulated recall discussions 77
4.6.6 Journal reflections 78
4.7 Data Analysis 79
4.8 Validity and Trustworthiness 80
4.9 Ethical Considerations 80
4.10 Dealing with ethical dilemmas using the Ubuntu perspective 81
4.11 Chapter Summary 84
CHAPTER FIVE: SCIENCE TEACHERS' PERSPECTIVES, PEDAGOGICAL INSIGHTS AND PRACTICES 85
5.1 Introduction 85
5.2 Findings That Emerged from the Sharing Circle 86

5.2.1 Science teachers' perspectives on the integration of IK into science teaching 86
5.2.2 Language difficulties and code-switching in the science classroom 89
5.2.3 Knowledge level of science teachers on the integration of IK in specific topics 91
5.2.4 Science teachers believe that IK enhances pedagogical understanding 94
5.2.5 The use of hands-on practical activities and visualisation 97
5.3 Pre-intervention Lesson Observations 100
5.4 Chapter Summary.....102
CHAPTER SIX: CAPACITY-BUILDING WORKSHOPS 103
6.1 Introduction 103
6.2 Pre-intervention Workshops.....104
6.2.1 Orientation workshop 104
6.2.2 Workshop on reflective journals.....107
6.2.3.1 Presentation by Sensei 110
6.2.3.2 Presentation by Inqununu 114
6.2.3.3 Presentation on document analysis 117
6.2.4 Data from co-analysing curriculum documents.....121
6.2.4.1 Enabling science teachers to identify content gaps between grades 121
6.2.4.2 Enabling science teachers to understand the necessity of integrating IK into science lessons 123
6.2.4.3 Active engagements stimulated learning 123
6.3 Chapter Summary.....124
CHAPTER SEVEN: TAPPING INTO THE CULTURAL HERITAGE OF INDIGENOUS KNOWLEDGE CUSTODIANS 126
7.1 Introduction 126
7.2 Intervention Workshops 126
7.2.1 Introduction 126
7.2.2 Data from Umhlekazi 127
7.2.2.1 How I got to know Umhlekazi 127
7.2.2.2 Umhlekazi's cultural heritage 128

7.2.3 Data from Majeke and MaMtshawe 135
7.3 Chapter Summary 141
CHAPTER EIGHT: KITCHEN CHEMISTRY 142
8.1 Introduction 142
8.2 Tapping into MaMcirha Funds of Knowledge and Cultural Heritage 142
8.2.1 The teachers found the presentation to be interesting, clear and informative 146
8.2.2 Allowed the science teachers to see the practical link between IK and WS 147
8.2.3 Exposed to learning opportunities on how to use IK in certain science topics 147
8.2.4 Learning affordances provided by hands-on practical activities 148
8.3 Reflective Space 149
8.4 Data from Hands-on Practical Activities and Visualisation by Nozinga 151
8.4.1 Introduction 152
8.4.2 Using easily accessible resources to do hands-on practical activities 152
8.4.3 Use of easily accessible resources stimulates excitement and promotes learning 156
8.4.4 Enabling and supporting learning 157
8.4.5 Power of practical activities as a learning affordance 157
8.5 Chapter Summary 158
CHAPTER NINE: CO-DEVELOPMENT AND ENACTMENT OF EXEMPLAR LESSONS 160
9.1 Introduction 160
9.2 Co-development of Exemplar Lessons 161
9.3 Summary of the Lesson on Redox Reactions 164
9.4 Summary of the Lesson on the Topic of Waves and Sound 173
9.4.1 Setting the scene 173
9.4.2 Lesson introduction 174
9.4.3 Lesson build-up 175
9.5 Data Presentation and Analysis 179
9.5.1 Soliciting learners' prior knowledge to enhance learning 179

9.5.2 Promoting interest and active participation 182
9.5.3 Promoting conceptual understanding 183
9.6 Chapter Summary 188
CHAPTER TEN: SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSIONS 189
10.1 Introduction 189
10.2 An Overview of the Study 189
10.3 Summary of The Findings 191
10.3.1 Findings related to research question 1 191
10.3.2 Findings related to research question 2 192
10.3.3 Findings related to research question 3 193
10.3.4 Findings related to research question 4 194
10.3.5 Findings related to research question 5 195
10.4 New Knowledge in the Study 197
10.5 Conclusion of Study 199
10.6 Recommendations 200
10.7 Limitations of Study 200
10.8 Areas for Future Research 201
10.9 My Reflections 202
References 205
Appendices 227
APPENDIX A: Research Ethics Clearance 227
APPENDIX B1(a): Permission Letter to the District Director of Sarah Baartman 228
APPENDIX B1(b): Response From the District Director of Sarah Baartman 229
APPENDIX B2: Letter to the Deputy Principal of XXX Combined School 230
APPENDIX B3(a): Letter to the Community Members 231
APPENDIX B3(b): Translation 231
APPENDIX B4(a): Letter to the Parents/Guardians 234

APPENDIX B4(b): Translation 236
APPENDIX B5: Letter to the Participants/Teachers 238
APPENDIX B6: Assent Letter to the Learner 241
APPENDIX C: Data-Gathering Tools and Methods 243
APPENDIX D: Research Process 245
APPENDIX E1: Semi-structured Interview Schedule 247
APPENDIX E2: Classroom Observation Schedule 248
APPENDIX F: Analytical Framework 250
APPENDIX G: TSPCK Components 251
APPENDIX H: Five Cognitive States 252
APPENDIX I: Concepts of SCT 253
APPENDIX J: Document Analysis 254
APPENDIX K: Hands-on Practical Activities Workshop 256
APPENDIX L: Data Analysis of MaMcirha's Presentation from Teachers' Reflections 261
APPENDIX M: Themes and Sub-themes From Sharing Circle 265

LIST OF FIGURES

Figure 2.1: Focusing within the third space (adapted from Glasson et al., 2010, p. 129) 26

Figure 2.2: The perspectives of the relationships between science and IK systems (adapted from Taylor & Cameron, 2016, p. 36) 28

Figure 2.3: Illustration of the CoP (adapted from Wenger, 1998, p. 3) 34

Figure 3.1: Showing the five components of TSPCK (adapted from Mavhunga & Rollnick, 2013, p. 115) 43

Figure 3.2: Consensus Model of PCK from PCK Summit 2012 (Gess-Newsome, 2015, p. 31) 45

Figure 3.3: RCM of PCK (Carlson & Daehler, 2019, p. 83) 46

Figure 3.4: The interface of the three complementary theories used in this study 49

Figure 4.1: The township school where the research was conducted 61

Figure 4.2: Map of Sarah Baartman District (https://www.ecdoe) 61

Figure 4.3: The three-phase model of learning. Adapted from TMESD of Figure 2 in Chikamori et al. (2019, p. 9) 64

Figure 4.4: Showing our sharing circle 69

Figure 4.5: Showing the stimulated recall discussions to validate the accuracy of the findings 78

Figure 6.1: Orientation workshop for our professional learning community 104

Figure 6.2: Learners reflecting to the teachers (pictures taken from the videos) 109

Figure 6.3: Showing our PLC listening to Sensei 111

Figure 6.4: Showing the process of the Lesson Study was illustrated by Sensei 112

Figure 6.5: Showing our PLC enjoying Inqununu's presentation 115

Figure 6.6: Ndlovu interacting with the groups during document analysis 118

Figure 6.7: Showing Madiba presenting to our PLC the data analysis of his group 122

Figure 7.1: A picture of Umhlekazi presenting to our PLC 129

Figure 7.2: Showing Majeke and MaMtshawe co-presenting to our PLC at the sea.....136

Figure 8.1: MaMcirha demonstrating how to make a dough (*intlama*) 144

Figure 8.2: MaMcirha demonstrating how to cook homemade bread (isonka samanzi).....145

Figure 8.3: Showing some of our PLC members in a Chemistry Lab 153

Figure 8.4: Showing science teachers sharing their findings.....155

Figure 8.5: Showing the colour change in the sugar after adding sulphuric acid 155

Figure 9.1a: Lesson Plan on redox reactions 162

Figure 9.1b: Lesson plan on waves and sound 163

Figure 9.2: Showing the class taught by Madiba 164

Figure 9.5: Showing the colour changes of various fruits during oxidation.....166

LIST OF TABLES

Table 4.1: Participants' profiles 63

Table 4.2: IKCs who participated in the study 63

Table 4.3: The tools, methods and purpose for the gathering of information 66

LIST OF ABBREVIATIONS AND/OR ACRONYMS

AASIKS:	African Association for Studies in Indigenous Knowledge Systems
ATP:	Annual Teaching Plan
CAPS:	Curriculum Assessment Policy Statement
CAT:	Contiguity Argumentative Theory
CoP:	Community of Practice
CPD:	Continuing Professional Development
DBE:	Department of Basic Education
DoE:	Department of Education
FET:	Further Education and Training
HDE:	Higher Diploma in Education
ICT:	Information Communications and Technology
IK:	Indigenous Knowledge
IKC	Indigenous Knowledge Custodian
IKCs:	Indigenous Knowledge Custodians
MKO:	More Knowledgeable Other
NCS:	National Curriculum Statement
PAR:	Participatory action research
PCK:	Pedagogical Content Knowledge
PIRLS	Progress in International Reading Literacy Study

PLC: Professional learning community

POGIL Process oriented guided inquiry learning

RCM Refined Consensus Model

SAARMSTE: Southern African Association for Research in Mathematics, Science and Technology Education

SAERA: Southern African Education Research Association

SCT: Socio-cultural theory

SMK Subject matter knowledge

SMT: School Management Team

TCPD: Teachers' Continuing Professional Development

TIMMS Trends in International Mathematics and Science

TSPCK: Topic-specific Pedagogical Content Knowledge

WS: Westernised Science

ZPD: Zone of Proximal Development

CHAPTER ONE: SITUATING THE STUDY

> In South African classrooms, learners experience cognitive dissonance when learning about certain phenomena in science classrooms. For example, the scientific perspective that lightning is caused by the discharge of electricity between clouds or from a cloud to the earth is in conflict with learners' cultural understanding that lightning is caused by, for example, witchcraft (Le Grange, 2007, p. 588).

1.1 Introduction

This chapter starts by outlining the background of the study. I then situate myself in the study as an attempt to help the reader of this thesis to understand my worldview. This is against the backdrop that a plethora of research exists highlighting the importance of recognising the learners' worldview for effective learning to take place (Asheela et al., 2021; Jegede, 1999; Mhakure & Otulaja, 2017). Next, I discuss my positionality and reflexivity. This is followed by the problem statement, the rationale, and the significance of the study, highlighting the gap that my study sought to fill in township schools in South Africa, followed by the research goal and questions. I then outline the theoretical frameworks that informed the study. Finally, I conclude with a chapter summary.

The South African Curriculum Assessment and Policy Statement (CAPS) encourages science teachers to use culturally responsive pedagogies in their teaching. This should be done by integrating indigenous knowledge (IK) in science teaching to make it accessible and relevant to learners. However, the policy falls short of giving clear details on how this ought to be done.

In this chapter, I situate my study whose focus was to apply the use of a Lesson Study approach when working with science teachers on how to integrate Indigenous Knowledge (IK) to mediate learning of the topics of waves and sound and redox reactions in a township school. Lenski et al., (2009, p. 50) stated that "The Lesson Study approach is a method of professional development that encourages teachers to reflect on their teaching practice through a cyclical process of collaborative lesson planning, lesson observation and examination of student learning". In our attempt to integrate IK during science lessons, we tapped into the cultural heritage and wisdom of the Indigenous Knowledge Custodians (IKCs) (Mateus & Ngcoza,

2019). This necessitated the use of Vygotsky's sociocultural theory (SCT) since social interactions were central to this study. However, because the main aim was the integration of IK to mediate learning to make science accessible and relevant, it became clear that SCT was limited and pedagogical content knowledge (PCK) was deemed necessary to complement the SCT as it focuses on teachers' pedagogical practices (Shulman, 1986). Also, PCK helped me to understand and interpret the transformation of subject matter knowledge to facilitate meaningful learning. However, PCK has its limitations as well, as it does not seem to address contradictions between knowledges that are suspected to be on opposite ends (Witt, 2021).

To harmonise the tensions that emerged during the research process, Ogunniyi's (2007a) Contiguity Argumentative Theory (CAT) was deemed appropriate in this study as it provided invaluable tools to analyse the teachers' engagements and arguments during our professional learning community (PLC) activities. This resonates with Govender's (2014) view that argumentation is critical to producing, evaluating, and therefore, advancing knowledge. Advancement of knowledge is critical in township disadvantaged schools so that they can become schools of excellence rather than being regarded as dysfunctional and exacerbated by the dissonance among learners as highlighted by Le Grange (2007) in the epigraph.

The study was conducted in a township school in the Eastern Cape, South Africa. What triggered my interest in this study was my upbringing and personal experiences as an African boy who grew up in the dusty streets of Tantyi location in Grahamstown (now called Makhanda) and the findings of my master's research project which focused on the learners (Mayana, 2020). In the current study, however, the focus was on science teachers in Grades 10 and 11. Since the integration of IK of the marginalised people of our country was central in this study, two complementary paradigms, viz. the Indigenous research and the transformative paradigms were intellectual homes and underpinned this study. They allowed me to appreciate the Indigenous participants' cultures and practices during the research journey. They also helped me navigate the slippery path of positionality in this study.

1.2 Context of The Study

The reality is that the decline in the number of learners choosing to do science in Grade 10 in South Africa, particularly in township schools, threatens the survival of Physical Sciences as a school subject and this is worrisome. This is evident in consecutive Trends in International Mathematics and Science (TIMMS) reports which revealed that South African learners perform

poorly in mathematics and science (Reddy et al., 2020), particularly in the Eastern Cape where this study was conducted. Accordingly, the Department of Basic Education's (DBE, 2017-2021) annual diagnostic reports indicate that the quality of matric results in Physical Sciences is poor. For instance, the 2021 diagnostic report shows that the number of level 7s (80% or more) had decreased (from 440 in 2019 and to 233 in 2021), in fact almost halved.

Some scholars argue that such a gloomy picture might be attributed in part to the decontextualised ways in which science is taught (Gwekwerere, 2016; Mothwa, 2011) resulting in learners experiencing cognitive dissonance as highlighted in the epigraph (Le Grange, 2007). Likewise, Aikenhead (2006) emphasises that teaching science is mostly done in Westernised ways which involve the use of Western materials and Western terminologies. Unfortunately, according to Erinosho (2013), such approaches to teaching science tend to alienate African learners as they make the subject too abstract and out of touch with the reality of their world. Similarly, Jegede (1999) cautions that any science curriculum that does not take into account the Indigenous worldview of the learner risks destroying the framework through which the learner is likely to interpret concepts. Indeed, a clear understanding of concepts is critical for meaning making and conceptualisation in science.

Various examiners' reports from the DBE (2017–2021) indicate that the concepts of waves and sound and redox reactions seem to be problematic for many learners. These reports indicate that most learners struggle to explain the concepts (or are unable to distinguish the concepts within these topics) related to the two topics and generally, these questions are poorly answered by most learners. Also, in the curriculum documents and textbooks, there is no reference made to the integration of IK.

To address some of these challenges, some scholars such as Klein (2011), Mutanho (2021) and Seehawer (2021), to mention a few, suggested that the use of IK should be seen as an alternative approach to assist in the teaching of science. In a similar vein, Mukwambo et al. (2014) advocate the Africanisation of the school curriculum, which they view as the introduction of methods and approaches in teaching and learning science that are relevant to the African context. Such debates resonate with the call that encourages science teachers to use culturally responsive pedagogies by integrating IK into science teaching (Mhakure & Otulaja, 2017) to make science accessible and relevant to learners (Asheela et al., 2021).

In addition, there is a need for cultural revitalisation as advocated by Cocks et al. (2012) and Smith (2012). This is in line with the post-apartheid and Bantu Education transformation agenda of making science relevant and accessible to township learners in particular in South Africa. It is against this background that this study sought to engage science teachers from a township school wherein an interventionist Lesson Study approach was employed to integrate IK to mediate learning of the topics of waves and sound and redox reactions as examples. I align myself with the scholars mentioned above, and perhaps my life history below would illuminate this.

1.3 Who Am I In This Study?

> *Xa ndinqumlela, ndiqhawuqhawula, ndilithol'iduna umnwanomngquba waseTanyi eRini, ndizalwa nguThemba unyana kaZinyusile, uSnini, yena ozalwa nguNtwayiyo, yena ozalwa lixhego ubawo uMayana, umfo waseKaladoko. NdinguMcirha, uNcibane, uNtswentswe, uNojaholo, uMhlanl'endlovu, uNyembezana. Ndingumtshana emaSukwinini, oLawu, oDibashe, oLubisi, oSandlalangca, oCwama, ewe mfondini umama nguKholiswa wakwaGotyana, iLawulentaba. Hayi mandiyeke, kodwa ndoba ndinetyala ukuba andikuxelelanga ukuba ndacela ukuzalwa eManywabeni, kwabawo uKulati, ukushoke, inkosikazi yakowethu, ngumaGatyeni, ndivumele ndingoluli mfondini* (I am from a Cirha clan with a genealogy that goes up to Nyembezana. My mother's clan name is MamSukwini, and my wife comes from eManywabeni, allow me to stop there in the interest of time). (Journal entry, June 2023)

The main reason for situating myself in the study is that I wish to make the reader of this thesis understand my worldview as alluded to earlier. In other words, it is my hope that exposing the reader of this thesis to my childhood experiences might enable him/her to understand my assumptions in life and how my upbringing and schooling influenced and shaped my worldview. Essentially, my journal entry above is a summary of my family tree, my gender, my clan name and my origin. In a Xhosa culture, a child is taught at an early stage to recite their family tree and it is emphasised in every social gathering that we should not be ashamed of our culture as it is the essence of our identity and that by and large shapes our worldviews.

My name is Xolani Justice Mayana. I was born in 1969 in Tantyi location, simply known as Tantyi or eTantyi, a small township in the city previously known as Grahamstown, now known as Makhanda. Only Black people and a few coloured people resided in Tantyi. The distance between Tantyi and town (the suburban area, an area reserved for White people only and business during those years) is roughly 10 km.

Childhood encounters with IK

My mother worked as a kitchen maid for White people, taking care of their homes (cleaning, hand washing their clothes and so on) and raising their children. She worked from Mondays to Saturdays. I remember she used to come home very tired, bringing leftovers from her employers for us to eat, which we enjoyed very much. It was my responsibility to wash her aching feet from long hours of standing. I recall she would ask me to add salt or Epsom Salt (Magnesium sulphate) to the warm water and massage her feet. According to her, that brought some relief to her pain. Little did I know that there was science in the process: only now, years later, have I learned that soaking feet in warm water with salt or Epsom Salt stimulates blood circulation, easing muscle cramps, helping to relieve stiffness in joints, and soothing achy overworked legs and feet (Sabitha, 2018). The question is, how did my mother know the benefits of using Epsom Salt dissolved in hot water with her standard six academic qualifications? Arguably, she was a more knowledgeable other according to Vygotsky (1978) but her knowledge and wisdom were not taken into consideration at school.

My father died when I was four years old so I cannot claim that I really knew him. Nonetheless, the *story* I was told was that he used to carry me on his shoulders to the rugby games, which was his favourite sport. My mother told me that my father gave me the name Xolani (which means be comforted) because their first-born child was a boy and they named him Thanduxolo (one who loves peace), but unfortunately, he died from an unknown disease before his first birthday. That brought distress to the entire family and stole their peace. The second born is Bongiwe, my elder sister. In an African culture, the first-born daughter is called *umafungashe* because later in life she would serve as a consultant to the family especially when it comes to cultural rituals. My children would refer to her as *udadobawo* (which translates to my father's sister) and hence during the cultural rituals Indigenous peoples would sing, "*Dadobawo sicela amandla*" (Father's sister we request power and strength).

I arrived as a third-born, a boy child, hence my father said to the family 'Xolani.' I can recall my mother's face glowing when she narrated to me the joy she and the family had when she gave birth to a boy child again. In African culture, it is hoped that a boy child is the one who would keep the family name, the one who would one day assist during traditional ceremonies and ultimately become an elder who would pass on the cultural heritage to the young siblings, both boys and girls (Haimene, 2023). In addition to my first name, my father also named me Justice because he wanted me to be a lawyer (attorney) and fight against the injustices of the

apartheid system which segregated people according to race and crippled their lives and livelihoods. So, it could be argued that my father had hopes and dreams, albeit his life was short.

In hindsight, however, one does not need to be an attorney to do justice and we need *justice* and *equity* in our education system as well. This is what this study was all about. For instance, even though I did not become an attorney I believe somehow, in my own way, I have contributed to the dismantling of apartheid (Mandela, 1994), because I was there in the early eighties (1980s) fighting against Bantu Education[2] (an inferior education system designed for Black people only). As a result, I lost two years of schooling because in 1984 and 1985 the schools were shut due to riots and instability. The country was under a state of emergency and all the boys in the township including me were under constant threat of either getting killed or jailed by the security forces or disappearing never to be seen again by their families. I also had to look after my youngest sister, Nobuhle (her name means the beautiful one), who was born two months before my father passed away in 1973. So, at 15 years old I had to play the role of a father. Fortunately, for me, I grew up at a time when the African adage which says, "It takes a whole village to raise a child" (Mbiti, 1977, p. 23) was prominent.

For instance, I remember that there were times when my mother was really battling financially. During those times she would send me to the neighbours to borrow some mealie meal or mealie rice to cook for supper. Indeed, our neighbours would give us other ingredients required to add without expecting us to return them, and that is Ubuntu (Ogunniyi, 2020; Seehawer, 2023). However, my mother taught me that when you borrow something from someone you must return it as promised. She would say, "*awumazi ungomso mntanam*" (meaning you do not know when you are going to need that person's help again). Even today that is one of my principles and I have adhered to it in life, and it has shaped my worldview. Looking back, therefore, I now can say my mother was an IKC.

Indeed, growing up at Tantyi was quite an experience. As African children we grew up playing together as boys and girls. We played games such as hide and seek (*undize*); the person who

[2]The Apartheid government provided separate and unequal education for Black and Whites in South Africa, through the notorious Bantu Education Act of 1953 (Ngcoza, 2007). Bantu Education was an inferior education provided to blacks pre-1994. It was not compulsory for Africans and was only free in primary grades. The government spent about six times as much for white students as on African students (Mandela, 1994, pp. 104-155).

would seek others would start off by singing "*ndize, ndize*" (meaning must I come and seek, they would wait until someone responds by saying "*yiza"* meaning come). There was mathematics involved in this game; for example, the person had to count the number of participants before the game started. Secondly, they had to wait for about 5 minutes before starting the search or they would be disqualified from the game if they started earlier. In hindsight, I believe that also taught us something about the importance of time management and rules (Sannino et al., 2016).

The other game we played was *upuca*. In this game, you would dig a nice round hole about 10cm deep and place 12 small stones and then throw up a stone and try to pull out some stones from the hole. You would then push the stones back into the hole. If you did not follow the rules you were disqualified. This game helped us to improve our fine motor skills which were crucial for writing and also helped us to improve our concentration skills as we had to focus amid distractions. I also learned later that this game could be used to explain chemical reactions.

Sasiphekisa namantombazana esifundisa ukupheka nokwabelana (As boys and girls we used to cook our little meals out there in the field). Each person would bring a little something; this taught us to contribute in life; girls (the more knowledgeable others [MKOs]) would teach us how to cook and we also learned how to share – that is Ubuntu, where relationships are at the centre of human interaction (Khupe, 2014). We had real human friends and not social media friends.

Teenagehood was probably the best stage of my childhood life because it was during this stage that I learned how to swim, and how to hunt birds and small animals like rabbits. At this stage, the elders would say "*yiyekeni inkwenkwe izonwabele*" (meaning let boys enjoy their boyhood or loosely translated, 'let boys be boys'). It was at this stage I started to be independent in terms of decision-making but at the same time dependent on teamwork to succeed. For instance, nobody taught me how to swim; I learned by observing others (a skill I now pass on to my learners during practical activities, for example, when I explain density and other science concepts in science lessons), but at the same time I was never forced to go with older boys to the dam or the river. It was my decision even though I knew very well that we were not allowed to go and swim because our parents feared that we might drown or *ndithwethyulwe* (a cultural belief that the ancestors could take you in and make you a traditional healer). I guess this is one of the reasons that one of the participants in this study is *igqirha* (a traditional healer also known

as a Sangoma) to verify the truth around this belief. I faced the consequences when I was caught but I have no regrets at all because when I became a father, I was able to teach my children how to swim and I guess this has taught me to be observant.

One of the things I enjoyed most was riding a donkey cart to the forest to fetch some firewood. At home we had an iron stove called *Welcome Dover* in the township, so it was one of my chores to fetch firewood and I learned to work hard and earn everything in life at an early age. Some of the firewood that we collected was sold to other people, so this also served as a source of income for our family. I learned how to make a fire (using small pieces of wood first, which talks to surface area and *cracking* in Physical Sciences) from my daily chores. All of these influenced my worldview; I was breastfed on Ubuntu all my life.

Earlier on I mentioned that I missed two years of schooling, but truth be told upon reflection I did not really miss school for the reasons that I will highlight briefly. Firstly, I did not miss school because at school the teachers used corporal punishment of the highest order for silly reasons such as getting 49 out of 50 marks (often I was in this category) which instilled so much fear in me. I literally feared going to school, but I was forced by my parents, and I went. Some kids dropped out of school, and I suppose corporal punishment contributed to the dropout rate and perhaps also led to broken homes and dropped dreams.

Secondly, I did not miss school because in most subjects we were taught to memorise without understanding and the examples used were not related to our sociocultural context as reiterated by Mavuru and Ramnarain (2020). As a result, what was taught at school was out of context and not relevant to our everyday life experiences (Gwekwerere, 2016). For instance, our English teacher in standard 4 who stayed in our area knew very well that the majority of us never went on a journey by train, but he would ask us to write an essay 'journey by train,' How I wish that he had asked us to write essays relevant to our upbringing such as a journey by donkey cart which was a common mode of transport at the time.

On reflection, I felt that there was this mountain between home and school (Tyeda, 2024), as "no one ever asked me what I was interested in nor did they ask for my consent to participate in their system" (Simpson, 2014, p. 6). Consequently, Simpson (2014, p. 6) reflected:

> My experience of education, from kindergarten to graduate school, was one of coping with someone else's agenda, curriculum, and pedagogy, someone who was neither interested in my well-being as a Cirha, nor interested in my connection to my homeland,

> my language or history, nor my Xhosa intelligence (my emphasis). No one ever asked me what I was interested in nor did they ask for my consent to participate in their system. My experience of education was of continually being measured against a set of principles that required surrender to an assimilative colonial agenda in order to fulfil those principles.

As pointed out in the quotation above I experienced what Le Grange (2007) referred to as cognitive dissonance. There were clear tensions between IK and Western Science (WS), and the schoolteachers did very little to accommodate my worldview.

In standard 8 (grade 10) I chose Physical Sciences; we did not do any experiments or hands-on practical activities (Asheela et al., 2021; Shinana et al., 2021). Instead, we relied on the textbooks and the notes the teacher made us to copy from the blackboard. Honestly, I did not enjoy the science lessons, but I was determined to pass and desperately wanted to be a medical doctor. So, I studied hard with little help from school, and I passed with good grades but not good enough to be accepted at a medical school. I was only introduced to practical work when I was doing my first year of BSc at Rhodes University and I failed my first year, as rote learning was not enough at this stage; it could not sustain me. Furthermore, the lecturers did not even try to relate science to my everyday life experiences (Taylor & Cameron, 2016). The following year I had to work to earn some money so that I could go to the University of Fort Hare the following year, and I did and obtained my BSc from the University of Fort Hare in record time.

So, it could be surmised that school and university in a sense alienated me (Mutanho, 2021). However, because I was taught to be resilient and trust God I survived. I am now a Physical Sciences teacher and am a headmaster of a successful school. This kind of childhood experience has influenced my worldview, which I believe has an influence on my positionality and reflexivity in the study.

To God be the glory, I am a born-again Christian and an ordained minister of the African Methodist Episcopal Church. I have experienced the healing power of Jesus Christ flowing through me and I have seen people getting healed supernaturally and delivered from demonic spirits and other illnesses and diseases (Matthew 10:8, NKJ Bible). Ecklund (2008, p.15) pointed out that: “Regardless of what scientists personally believe about matters of faith, religion and science are often connected in a surrounding social environment”. I am 54 years old now and my experience has taught me that nothing in this world can be understood merely through the lens of one dominant knowledge but through several bodies of knowledge.

Even though I did not become a medical doctor my passion for helping the sick has been supernaturally realised. So, based on my life experiences I align myself with Aikenhead and Ogawa's (2007) standpoint that the perceived differences between WS, IK and religion do not necessarily mean there is a disjuncture between these knowledges. Seehawer (2018) emphasises that when one engages with Ubuntu, it is important to make it clear that human beings in an African context (as in the context of this study) are not separate from nature but there is that interconnectedness. Similarly, Hart (2009, p. 35) points out that there is a "recognition that there is another existence that is not of the physical world". This is a phenomenon that will permeate this study. This is why Ogunniyi's (2007a) CAT as an analytical lens in this study to harmonise and assist me in understanding the intersection of these worldviews is appropriate. Based on what I heard growing up, the following cultural practices were targeted in this research, *ukuhlwayela, ukuthwethyulwa* and *ukunyela kwesonka* (to plant a seed, a cultural belief that the ancestors could take you in and make you a traditional healer and when homemade bread becomes damp during the cooking process) it was hoped that the IKCs would explain these and other related practices and also do practical demonstrations of these practices.

1.4 My Positionality and Reflexivity

The term positionality refers to both the researcher's worldview and the position that they take with regard to the research project (Holmes, 2020; Thomas, 2013). Positionality is not about position only. It is about ethnicity, culture, language, marital status, number of years of being a man in an African context (*izilimela*[3]), qualifications and so on. All of these can influence the research process (Keane et al., 2016). In this regard, Thomas (2013) claims that a researcher has an undeniable position in the research process and this position affects the nature of the observations and interpretations and the conclusions that they make. In a similar vein, Holmes (2020) avers that an individual's worldview (like mine) affects their beliefs about the nature of social reality, what is knowable about the world and their views about the nature of knowledge. In other words, as indicated above, positionality is more than just a power gradient or power dynamics: it includes other aspects such as culture, ethnicity, language, marital status and much more.

[3]*Isilimela* is the month June in isiXhosa and the number of years for manhood is counted in accordance to this month as it was common practice in the past for boys to be taken to the circumcision school in June (Ngcoza, 2017).

In that regard, it is important that I, as a researcher, paid attention to my positionality in relation to the study. For instance, as a school principal and an experienced physical sciences and mathematics teacher who has produced distinctions and quality results over the years, my participants might think that I knew it all. Resultantly, I positioned myself as a co-learner since all of us seemed to battle with integrating IK into our teaching as explained in the background section of this study. Furthermore, in my personal experience, in the Xhosa culture, clan names are used to level the power gradients or to put everyone on the same level and in this study, as in Mutanho's (2021) study, we used clan names to address each other as a sign of respect for all participants. Moreover, in the context of my study, the IKCs were regarded as more knowledgeable others (MKO). In other words, the power gradient favoured the IKCs. This helped level the power dynamics and made the participants feel they owned the study and as a result, they were proactive and made suggestions.

Secondly, I ensured that none of the participants were coerced or obliged to participate in this study by applying Ubuntu as I negotiated consent. For instance, I found a polite way to explain to them that they could withdraw at any given time if they so wished (*Ungayeka nanini na xa ufuna*), as required by Rhodes University's ethical protocols (Keane, 2021). As a Xhosa man, I am aware and mindful of the tension caused by asking someone who has willingly volunteered to participate in your study to withdraw at any given time if they so wished, which in my culture is perceived to be rude and careless, especially when you talk to elders. In his study conducted in South Africa at a Higher Education Institution, Mutanho (2021) argues that this statement needs to be carefully translated and applied as it is inappropriate in many cultures in Southern Africa. He goes on to offer Ubuntu as an alternative that could be used to deal with relational issues in research.

I applied Ubuntu by visiting the IKCs who were all isiXhosa speaking in their homes as a sign of respect and followed isiXhosa protocols in negotiating with them. I used isiXhosa to explain the purpose of the study in detail and everything else, including their roles. I then requested their written consent and permission to videotape (as it is required by my university) the presentations when they fully understood my position and the context in which the study would be conducted (Cohen et al., 2018). Although the IKCs involved in this study were not as educated as the science teachers they were the more knowledgeable (Vygotsky, 1978) about the cultural heritage and hence referred to them as IKCs in this study.

Moreover, their status as elders in our community alone positions the IKCs as having distinctive power. I also made it clear to all the participants that I intended to conduct the study *with* them and not *on* them (Ngcoza & Southwood, 2015) as alluded to earlier. Thus, freedom of expression was always encouraged in this study. It is worth mentioning that even though I am a school principal in terms of science and mathematics the deputy principal (who was also a participant in this study) was the head of the department, which means I was accountable to him and that positioned him as my head. We also invited three critical friends, two university lecturers, and one school principal from Zambia as the MKOs to conduct workshops on document analysis and Lesson Study. Lesson Study is a form of teacher development that is collaborative and cyclical and aimed at improving teaching through reflections (Alshwaikh & Adler, 2017). This underlines that we were co-learners and benefitted professionally. Notwithstanding, it was important for me to be reflexive throughout this research process.

Holmes (2020) believes reflexivity helps the researcher to be conscious of various important aspects of the participants' lives, such as their culture, social values, and norms and values of their social context so that the researcher does not affect their emotions negatively during the research process. Guided by Holmes (2020) in terms of reflexivity, I conducted continuous reflections and took some actions throughout the research process. For instance, I was reflexive during workshops with the teachers and presentations by the Indigenous Knowledge Custodians (IKCs) and I did not impose on them which language to use and how to present. I believe that encouraged everyone and made them more comfortable to participate in this study.

1.5 Statement of The Problem

The South African Curriculum Assessment and Policy Statement (DBE, 2011), commonly known as the CAPS, stipulates that science teachers should integrate IK into their teaching. Unfortunately, it does not provide clear guidelines on how to go about enacting this. Instead, it is left to the individual teacher's discretion and expertise to integrate IK into their science lessons as they see fit (Khupe, 2014; Mutanho, 2021). In this regard, Ngcoza and Southwood (2015) aver that there is tension between the intended curriculum and the implemented curriculum, something which ultimately has a negative impact on the attainment by learners as alluded to earlier. This is because the teachers, who are important agents of any curriculum change, are left out of important decision-making which impacts curriculum implementation.

Research shows that in many cases, teachers are not properly trained or supported to implement such a radical shift in policy (Bantwini, 2012; Jacobs, 2015). Furthermore, the professional development workshops (run by the Department of Education which I have also attended) usually last a few hours and have very little to offer in this regard. During those workshops, for instance, teachers are expected to take down notes, and usually, there is little room for discussion if at all, and certainly no reflections by the teachers. Yet, teachers are expected to go back to their respective schools to implement what has been dictated to them. Such an approach could result in poor or no implementation at all. Therein lies the importance of using a Lesson Study approach, working *with* science teachers on how to integrate IK to mediate learning on the topics of waves and sound and redox reactions as examples.

There have been several studies on the integration of IK into science in Namibia and South Africa in the Rhodes University Science Education Department (Hashondili, 2020; Mayana, 2020; Mutanho, 2016, 2021; Shinana, 2020). My study is part of this research programme. For instance, Liveve (2017) did his research on traditional music and dance and revealed that traditional music and dance enabled learners to make sense of physics concepts related to sound. Unfortunately, his study focused mainly on sound and made very little reference to waves, exposing a gap that my study hopes to close. Likewise, Mayana's (2020) study whose main goal was to explore whether learners' dispositions, conceptions, and sense-making were influenced by integrating IK when teaching the topic of waves and sound in a Grade 10 Physical Sciences township class, focused on learners and not on teachers. This current study focused on science teachers to build their capacity in IK integration.

Essentially, six main knowledge areas inform the subject of Physical Sciences outlined in CAPS in South Africa (DBE, 2011, p. 8), viz., Matter and Materials, Chemical Systems, Chemical Change, Mechanics, Waves, Sound and Light, and Electricity and Magnetism. I chose to research waves, sound, and redox reactions because they are some of the most failed topics in grade 10 and 12 examinations. For instance, for the past five years, examiners' reports show that many learners who attempted the questions on these topics did not do well (DBE, 2017–2022). It is recognised, however, that a solid foundation from the lower grades is vital in order to have and sustain good results in grade 12 (DBE, 2011). It is my hope, therefore, that this study might provide science teachers with an opportunity to strengthen these areas and others, to assist their learners in understanding these topics and other topics better, and ultimately improve results.

In this study, I relied on the cultural heritage and wisdom of the Indigenous Knowledge Custodians (IKCs); hence, I positioned myself as a co-learner who had vague knowledge about cultural practices related to the sea and *isonka samanzi*. Based on what I heard growing up, the following cultural practices were targeted in this research, *ukuhlwayela, ukuthwethyulwa* and *ukunyela kwesonka* – it was hoped that the IKCs would explain these and other related practices and also do practical demonstrations of these practices.

1.6 Purpose and Significance of the Study

The purpose of this study was to use a Lesson Study approach when working *with* science teachers on how to integrate IK to mediate learning about waves and sound and redox reactions in a township school. As alluded to earlier, this was intended to make science accessible and relevant to teachers and ultimately to learners as beneficiaries. Furthermore, the integration of IK could be used for revitalising and building respect for culture as well as restoring the identities of learners, teachers and community members (Cocks et al., 2012; Smith, 2012).

This study is significant in that its findings could provide insights into how to integrate IK into science teaching by tapping into the cultural heritage of IKCs on waves and sound and redox reactions. It is also hoped that the study might help science teachers select pedagogies grounded in IK which would take into consideration the worldview of their learners as espoused by Mukwambo et al. (2014) and other scholars.

Furthermore, through workshop discussions, the study has the potential to provide an opportunity to co-develop much-needed resources that integrate IK as was the case with Seehawer's (2018) study. It may also provide a much-needed opportunity for continuing professional development (Ngcoza & Southwood, 2019) or building a PLC (Brodie, 2013; Chauraya & Brodie, 2018) for science teachers in a township school. It is hoped that the experiences of our PLC in this study might have some domino effect on the entire school and help *sustain* and improve the academic excellence of the school. On a personal level, as a Physical Sciences teacher, the study might provide me with an opportunity to extend the knowledge gained during my master's research and help me to improve my own teaching practice.

1.7 Research Goal and Questions

The main goal of this study was to use a Lesson Study approach when working *with* science teachers on how to integrate IK to mediate learning of the topics of waves and sound and redox reactions in a township school. To achieve this goal, the following research questions were addressed:

Research questions

1. What are the science teachers' perspectives, pedagogical insights, and practices regarding integrating Indigenous Knowledge in science teaching?
   (a) What are science teachers' perspectives and pedagogical insights regarding integrating Indigenous Knowledge into their teaching before the intervention?
   (b) What are science teachers' classroom teaching practices before the intervention?
2. What learning opportunities were created for the science teachers who are in a learning professional community through capacity-building workshops by critical friends before the intervention?
3. What learning opportunities were created (or not) during the presentations by the Indigenous Knowledge Custodians?
4. What learning opportunities were created (or not) during hands-on practical activities on kitchen chemistry?
5. How did science teachers co-develop and then enact their exemplar lessons that integrate Indigenous Knowledge into the teaching of waves and sound and redox reactions?

1.8 Theoretical and Analytical Frameworks

Central to this study was the capacitation of science teachers on how to integrate IK into their science lessons. It is with this understanding that the overarching theoretical framework informing this study is Vygotsky's (1978) SCT. In his seminal work, Vygotsky (1978) suggests that learning is a cultural process in which social interactions play a vital role. Moreover, language as a cultural tool for communication is also significant during social interactions. In the context of this study, the science teachers positioned themselves as learners and the IKCs and my critical friends were regarded as the more knowledgeable others (MKOs) (Vygotsky,

1978). We tapped into the cultural heritage and wisdom of the IKCs (McRobbie & Tobin, 1997) in our attempt to integrate IK during science lessons.

In addition, the study also involved reconceptualising the science teaching activity by exploring new ways of teaching science to make science accessible and relevant. It is these limitations of SCT to this study that necessitated the use of Shulman's PCK. Shulman (1986) argues that PCK refers to teachers' understanding and interpretation of the subject content, and thereafter the transformation of subject matter knowledge to facilitate meaningful learning. Shulman emphasises the importance of the ability to transfer knowledge to the learners. However, Shulman's PCK has been challenged and its limitations exposed and as a result, a Refined Consensus Model (RCM) was developed by Gess-Newsome (2015). This new model of PCK presents teachers' professional knowledge in three domains, namely, collective, personal and enactment (Carlson & Daehler, 2019). In this study, we used Mavhunga and Rollnick's (2013) topic-specific PCK (TSPCK) because it can transform specific content such as waves and sound and the redox reactions in a way that is understandable to learners at a given level and context (Shinana et al., 2021). Furthermore, learning is a complex process with some contradictions and tensions, in my case between Indigenous Knowledge (IK) and WS.

In response to this reality and to augment the SCT and PCK, I used Ogunniyi's (2007a) CAT as an analytical framework. Ogunniyi (2007a) asserts that argumentation happens when two different cultures co-exist such as IK and science and can only be possible through cognitive shifts to accommodate each other. Effectively, CAT can be applied to harmonise two distinct worldviews such as IK and WS (Ogunniyi, 2007a). For that reason, the CAT was deemed appropriate in this study as it was hoped that it might provide an invaluable platform to analyse the teachers' engagements and arguments during our PLC activities. Govender (2014) asserts that argumentation is critical to producing, evaluating, and therefore, advancing knowledge. Within CAT, I drew on the five components, viz. dominant, suppressed, assimilated, emergent and equipollent as my lenses to analyse ideas that emerged during the social interactions (Vygotsky, 1978). The CAT helped me understand the teachers' input during interactions and when analysing their journal reflections.

1.9 Definition of Key Concepts

I have used many concepts that could have different meanings in other contexts and settings or could be written differently. Considering this, I will explain below the meanings these terms are meant to convey in this study or the way I decided to write them in this thesis.

Indigenous Knowledge Custodians (IKCs): I use this term when I am referring to elderly people from a township who are the custodians of the cultural heritage (Mutanho, 2021).

Ubuntu: This is an African-centred worldview that emphasises the good of all, harmony, mutual respect, understanding of relations, interdependence, interrelationships, and interconnectedness of all phenomena (Chilisa, 2012).

Indigenous Knowledge (IK): Specific forms of knowledge that are local and specific to a place (Nyika, 2017). In different areas, IK is given different labels, such as "indigenous knowledge systems", "traditional knowledge", "traditional ecological knowledge", and other related terms. In this study, I have chosen to use IK or local knowledge interchangeably.

Professional learning community (PLC): This is an organised group of people who meet regularly during the study to share expertise and work collaboratively as a form of action research to improve teaching skills and the academic performance of learners. It had the focused role of helping to bridge learners' cultures with that of the schools in an effort to close the cultural gap that exists between formal and informal education by positioning the PLC members as the cultural knowledge brokers.

Cultural Knowledge Broker: In the context of this study, it is a concept used to describe the science teachers from a township school who acted as intermediaries and negotiated between outwardly different cultures, languages, and social and political systems (Wyatt et al., 2017).

Local: Applied to different geographic contexts, but it lacks specificity.

Curriculum: In the context of the study, it refers to the summary of concepts to be taught to learners to help them meet the content standard of Physical Sciences (DBE, 2011).

Prior Everyday Knowledge: This is the kind of knowledge that the learners possess and explore through their social interactions and learning through communication with others (Kuhlane, 2011).

Culture: This is a set of beliefs and practices which provide opportunities for human beings to be agents of their destinies. It is both a way of life for people and an agenda within which they make meaning, challenge differences and initiate change (Chilisa, 2012).

Positionality: It reflects the position that the researcher has chosen to adopt within a given study.

Reflexivity: This entails reflecting and taking action throughout the research process.

Waves: These are a type of energy transmissions that result from a periodic disturbance (vibration) and are composed of a series of repeated patterns.

Sound: A phenomenon we experience when our ears are disturbed by vibrations in the air/solid objects that surround us.

Social interactions: This is the mechanism of sharing ideas and a method of understanding these ideas.

Mediation of learning: This is the connection between the existing states of mental development through the ZPD.

Zone of Proximal Development: This is the distance between the actual development level as determined by the independent problem-solving of an individual and the level of potential development as determined through problem-solving in collaborating with more capable peers.

Scaffolding: Rojas-Drummond et al. (2013, p. 12) defined scaffolding as the temporary support and gradual withdrawal and "transferring of responsibility to novices so as to promote the eventual appropriation of knowledge and abilities as well as self-regulation".

1.10 Thesis Outline

This thesis consists of 10 chapters as outlined below.

Chapter One is an introductory chapter aimed at situating this study. It started with a brief introduction after which I presented my own experience as an African child highlighting the tensions between IK and school. I then discussed my positionality and reflexivity. Thereafter, the chapter focused on the statement of the problem, the purpose of the study, significance of the study as well as the research questions followed by the theoretical lenses that guided this

study. The chapter ended with a brief presentation of the key concepts of this study, a thesis outline and a chapter summary.

In **Chapter Two** the literature related to the study is reviewed. I will introduce the concepts that fall within the conceptual framework. Thereafter, the hands-on practical activities, visualisation and PLC are discussed, followed by the conclusion of the chapter.

Chapter Three discusses the theoretical lenses that informed this study. These lenses were the SCT, PCK and the CAT. These three were used as complementary theories after it was found that Vygotsky's SCT alone could not account for the transformative learning that took place in this study. In this study, the participants were science teachers who positioned themselves as co-learners and the MKOs were the elders from the community, four critical friends who were university lecturers and one school principal from Zambia.

Chapter Four deals with the methodology followed when conducting this study. I used a Lesson Study approach and worked with six science teachers from a township school in the Sarah Baartman District, in the Eastern Cape, South Africa. In this qualitative case study, I employed the transformative and Indigenous paradigms. Within the Indigenous paradigm I focused on the Ubuntu perspective since we were working with community elders and tapping into their cultural heritage. Furthermore, sampling techniques used to select participants are discussed in this chapter. The PLC and participatory action research (PAR) were used as research approaches and various data-gathering methods are clarified to answer the research questions. I will further explain how data generated were analysed usin inductive-deductive data analysis.

Chapter Five presents data generated using sharing circles discussions and pre-intervention lesson observations. The data-gathering methods helped generate data to address research question 1, which wanted to understand the teachers' perspectives and pedagogical insights on the integration of IK into science lessons. Sub-themes emerged from the data, and they were developed into themes inductively and deductively.

Chapter Six presents data from workshops. The main aim of the workshops was the capacity-building of science teachers involved in this study. I first explore the science teachers' interactions, their participation and learning (or not) during the pre-intervention workshops by three critical friends to answer research question 2. Two of the teachers gave a presentation on Lesson Studies via Zoom (one university lecturer from Japan and one school principal from

Zambia). The third critical friend who was also a university lecturer did a presentation on document analysis and how to use the TSPCK and literature to analyse data. Data gathered in this phase helped me to answer research questions two, three and four of the study.

Chapter Seven explores the engagements of the science teachers during the presentations by the IKCs, namely, Umhlekazi, Majeke and MaMtshawe. Data gathered during the presentations helped answer research question 3.

Chapter Eight presents the data generated from the two practical demonstrations on kitchen chemistry. The first practical demonstration was conducted by MaMcirha, an IKC who demonstrated how to make *isonka samanzi* (homemade bread). The second hands-on practical was conducted by Nozinga, a critical friend from Rhodes University who demonstrated how to do practical activities using easily accessible resources (Asheela et al., 2021). The data gathered from the practical demonstrations helped me to answer research questions 3 and 4.

Chapter Nine outlines the data generated during the co-development of exemplar lessons by science teachers, followed by the summary of the lesson observation on redox reactions which was taught by Madiba. Thereafter, the chapter presents the data generated during the lesson presentation by MaNgconde on waves and sound. Data generated was used to answer question 5, which sought to know how science teachers co-developed and then enacted their own exemplar lessons that integrated IK on the topics of waves and sound and redox reactions as examples. In this chapter, I assessed the impact of the intervention on the teachers' understanding of the integration of IK during the lesson on redox reactions and the lesson on waves and sound.

Chapter Ten outlines the overview of the study. Thereafter, summarises the findings of my study, guided by the research questions and the new knowledge that emerged from the research. After this, I present the conclusion of the study. The recommendations and limitations of the study are also discussed in this chapter. I thereafter share my research journey, experiences, and personal reflections.

1.11 Chapter Summary

In this chapter, I situated my study by presenting the background, discussing the purpose of the study, the research questions as well as the significance of the study. The chapter also presents an outline of chapters. This chapter presented the intrinsic nature of the study by looking at the

theoretical frameworks that were used to analyse the data generated from the six research processes. The six research processes used to generate the data are discussed in Chapter Four. The next chapter deals with the literature review relevant to the study.

CHAPTER TWO: LITERATURE SYNTHESIS

> … let me say that the story of using storytelling was here before me. I was born into the story, I have gained from the story, I am sharing this story with you and … although I will leave the story, the story will go on. (Mucina, 2011, p. 12)

2.1 Introduction

Hart (2018) defines a literature review as the analysis, critical evaluation, and synthesis of existing knowledge relevant to a research problem. In this chapter, I thus discuss literature relevant to my study, namely, waves and sound, redox reactions, prior knowledge, IK and Ogunniyi's CAT as an analytical lens, teachers' perspectives on the integration of IK into teaching, hands-on practical activities and visualisation and professional learning communities.

In this study, I position myself as an integrationist as I believe that Indigenous knowledge (IK) and Westernised science (WS) have the potential to complement each other rather than being seen as mutually exclusive. Research shows that there is a yawning gap between what learners learn from home (IK) and what they learn at school (WS) as reiterated by Kuhlane (2011). So, the integration of IK (amalgamation or combination) in this study explored the use of prior everyday knowledge which could be in the form of IK to close the gap between home and school as explained in Section 2.4. This could be done by employing ways consistent with the nature of WS while at the same time being responsive and relevant to the learners' worldviews. Thus, the study proposes that IK and WS should be interwoven/amalgamated during the teaching and learning of science. As a result, in this study, these knowledges are not polarised, what Ogunniyi (2007) refers to as an equipollent cognitive state. Now, I discuss the literature related to my study.

2.2 Waves and Sound in the Curriculum

In South Africa, the Physical Sciences curriculum is made up of physics (Paper 1) and chemistry (Paper 2). Waves and sound are part of paper one in the physics section. As alluded to earlier, various examiners' reports from the DBE, 2017-2021) indicate that the concepts of waves and sound seem to be problematic for many learners. This means that the questions that

require learners to explain these concepts are poorly answered by most learners. For instance, according to the CAPS, learners are expected to explain constructive and destructive interferences of pulses. Furthermore, they are expected to explain what superposition is, that is, the addition of the disturbances of the two pulses that occupy the same space at the same time.

There are specific calculations that the learners are expected to do on the topic of waves and sound. However, before they can do such calculations, they are expected to know the relationship between certain concepts, for example, between frequency and period and how they relate to the speed of a wave ($v = f\lambda$). This is a critical skill that the learners should acquire, and is in line with one of the general aims of the South African Curriculum which states that:

> Equipping learners, irrespective of their socio-economic background, race, gender, physical ability or intellectual ability, with the knowledge, skills and values necessary for self-fulfilment, and meaningful participation in a society as citizens of a free country. (DBE, 2011, p. 4)

Indeed, life is about relationships. Even more so, how those relationships are interrelated is pivotal. Physical Sciences as a subject is no exception in this regard. Science learners should therefore know and understand those relationships for meaningful learning to take place. For example, sound is a pressure wave that passes from particle to particle in a medium, and the pitch of the sound (how high or low it is) depends on the frequency of the pressure waves. Similarly, loudness is related to the amplitude of the sound waves. The basic elements of sound are amplitude, propagation medium and length (Kadis, 2015). According to CAPS, learners are expected to explain the relationship between wave speed and the properties of the medium (gas, liquid or solid) in which it travels (Liveve, 2017). The topic on waves also covers ultrasound and electromagnetic (EM) radiation which is different from sound waves.

Based on my more than 20 years' experience as a science teacher, I have learned that it is extremely difficult to explain to a grade 10 learner how two pulses that reach the same point in the medium superimpose constructively or destructively and then continue in the original direction of motion, even when we use diagrams (representations) to illustrate this phenomenon. To me, this suggested the need for alternative approaches to teaching. I believed that Mavhunga and Rollnick's (2013) TSPCK might help address this challenge. As indicated earlier in Section 1.8.2, TSPCK has the capacity to transform specific content such as waves and sound and the redox reactions in a way that is understandable to learners at a given level

and context (Shinana et al., 2021). It was hoped that the five components of the TSPCK would assist the teachers during the analysis of curriculum documents. In addition to waves and sound, another topic of interest in this study was redox reactions.

2.3 Redox Reactions in the Curriculum

The topic of redox reactions falls under Chemical Change. According to CAPS (DBE, 2011, p. 35), "a chemical change is a change in which the chemical nature of the substances involved change, and new chemical substances are formed". In other words, a chemical change is the formation of new substances (products) which are different from the initial substances (reactants), through a process known as a chemical reaction (Du Toit, 2017; Kakambi, 2020). In a chemical change, bonds are broken, and new bonds are formed, and sometimes, depending on the type of reaction, loss and gain of electrons take place resulting in a conversion from one state of matter to another. There are different types of chemical reactions. A chemical reaction in which there is a change in the oxidation numbers of atoms going from reactants to products is known as the oxidation-reduction reaction or redox reaction (Chang, 2008; Du Toit, 2017).

The topic of redox reactions is dominated by several concepts, including oxidation numbers, oxidation half-reaction, reduction half-reaction, oxidising agent, reducing agent, anode and cathode. In addition, learners are expected to be able to balance redox reactions and perform related calculations. Unfortunately, the examiners' reports have shown that questions on redox reactions are poorly answered in the grade 12 National Senior Certificate examinations (DBE, 2017-2022). For instance, the reports indicate that learners cannot distinguish between a reducing agent and an oxidising agent or how to identify the anode in an electrolytic cell. This suggests that redox reactions seem to be one of the challenging topics for science learners (Obomanu & Onuoha, 2012; Paik et al., 2017). To me, this problem provided a solid starting point for our community of practice during the document analysis, central to which was co-learning (Lave & Wenger, 1991; Wenger, 1998). The examination guidelines, the Annual Teaching Plans (ATP), various textbooks, and the examiners' reports were used to design exemplar lessons that integrated IK. I thought prior everyday knowledge (Kuhlane, 2011) might also be useful during the co-learning of redox reactions.

2.4 Prior Everyday Knowledge

Okanlawon (2012) defines prior knowledge as "a body of information that students 'bring to the table' before engaging in instruction and use to make meaningful connections between concepts, information or strategies that have to be learned" (p. 390). Previous knowledge serves as a cognitive scaffolding as explained by Brunner (1966), allowing learners to build on what they already know by making connections between home and school knowledge. In other words, prior knowledge is learners' existing knowledge before instruction (Hewson & Hewson, 1988). Similarly, Roschelle (1995) indicates that a large body of findings shows that learning proceeds primarily from prior knowledge. Hence, Roschelle (1995) warns that neglecting prior knowledge can result in the learners learning something different from the teachers' intentions.

In that regard, Kuhlane (2011) suggests that science taught in school should be meaningful and should take into consideration what the learners already know from their homes or communities. Concurring, scholars such as Mavuru and Ramnarain (2020) extend Vygotsky's (1978) seminal work and emphasise the importance of taking into consideration learners' sociocultural backgrounds. However, Taylor (1999) warns that not all prior knowledge is educational. This suggests that any misconceptions embedded in learners' prior knowledge need to be cleared up and corrected. It is also recognised that prior knowledge could be in the form of IK (Hashondili, 2020).

2.5 The Nature of Science and the Nature of Indigenous Knowledge

Literature reveals that the nature of WS is based on the logical positivism epistemology, which views scientific knowledge as a product from an empirical base which is universal and rational (Aikenhead & Ogawa, 2007; Glasson et al., 2010). This view has been adopted as a guiding principle by curriculum developers in many countries, South Africa included. In this regard, Onwu and Mosimege (2004) and Shizha (2007) proffer that this aspect of the nature of science has been used as a 'gatekeeping' strategy to determine what to teach and how to teach it in many science classrooms.

On one hand, IK is cumulative knowledge, based on the daily experiences of community members, and is passed on from generation to generation through *storytelling*, traditional dance, paintings and other artefacts (Kibirige & Van Rooyen, 2006; Nhase & Dube, 2023). IK seeks to understand systems as wholes, not as fragments and is rooted in people's culture and

indigenous ways of knowing, refined over time (Jones & Hunter, 2003). Unlike other knowledge bodies, IK is not concerned with testable phenomena and logical deductions; instead, it is gained by careful observations of nature and natural phenomena over many years, trial and error experiments and daily experiences of Indigenous Knowledge Custodians (IKCs) who are the custodians of the cultural heritage.

It is not the focus of this study to compare WS and IK, but rather to explore how teaching and learning of the topics of waves and sound and redox reactions in a township school can be improved and enhanced by integrating IK into science lessons. This could be done by employing ways consistent with the nature of science while at the same time being responsive and relevant to the learners' worldviews to make science accessible (Mhakure & Otulaja, 2017; Taylor & Cameron, 2016). It could be argued, then, that the integration of the two knowledge systems is both a way for the local culture to gain better access to school science and a way for the young generation to appreciate their cultural values (Baquete et al., 2016; Glasson et al., 2010). In this study, I was interested in the third space as demonstrated in the diagram below.

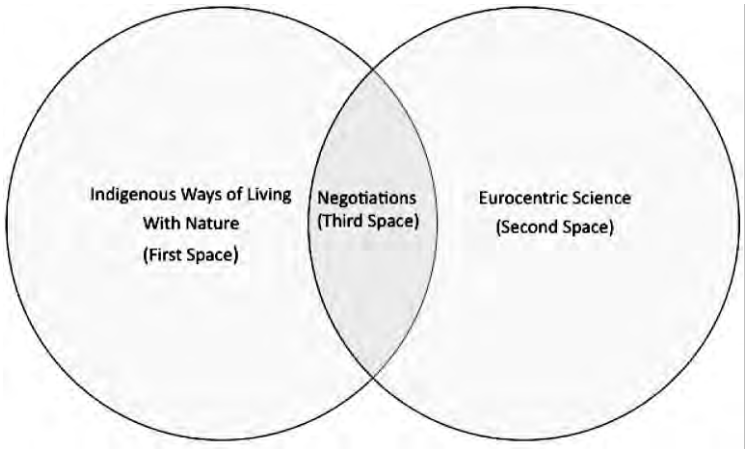


Figure 2.1: Focusing within the third space (adapted from Glasson et al., 2010, p. 129)

"Within the third space, stakeholders (e.g., learners, teachers, curriculum developers, community elders) collaborate together in the construction of new hybrid meanings and interpretations of science" (Glasson et al., 2010, p. 129). The perceived differences between WS and IK do not necessarily mean there is a disjuncture between these knowledges (Aikenhead & Ogawa, 2007) and polarising them was not the contention of this study. Hence the need for this study whose focus is on the intersection of IK and WS as shown in Figure 1 above. In that regard, Ogunniyi's (2007) CAT is deemed relevant to serve as a crucial analytical

lens to harmonise these two worldviews. In the next section, I will explain in detail my understanding of IK.

2.6 What is Indigenous Knowledge?

> Indigenous knowledge includes knowledge about agriculture and food production, pastoral practices and animal production, forestry, plant classification, medicinal plants, management of biodiversity, food preservation, management of soil and water, iron smelting, brewing, making dwellings and understanding astronomy. (DBE, 2011, p. 8)

From this description, it is evident IK refers to a large body of knowledge and skills that has been developed outside the formal education system, and which enables communities to survive (Klein, 2011; UNESCO, 1999). Kibirige and Van Rooyen (2006) also view IK as a legacy of knowledge and skills that are unique to a particular local culture and involve wisdom that has been developed and passed on over generations. Moreover, IK, also called traditional knowledge, local knowledge, or traditional ecological knowledge, refers to the indigenous peoples' knowledge that they gathered over generations and is used for their survival (Kibirige & van Rooyen, 2006; Klein, 2011). In this study, the term IK was consistently used. In the context of this study, IK refers not only to knowledge of the past but also to the contemporary IK that people use in their everyday lives.

My view of IK in this study is informed by the understanding that IK, like any other knowledge system, is dynamic. It is not static but rather evolves with time; for instance, before *isonka samazi* our ancestors made *isonka sothuthu* (placed the dough on ashes) which has led to the bakery we see today. When I was a little boy, for instance, I used to listen to *stories* told by *utamkhulu* (my grandfather) on how they treated colds and flu using Indigenous plants such as *umhlonyane* (an African herb).

When we were growing up *utamkhulu* made us drink *umhlonyane*, as a result, we hardly suffered from colds and flu as little children in our home. This resonates with Shiza and Emeagwali's (2016) confirmation that the traditional plants that were used by Indigenous people had healing properties. In other words, *utamkhulu* was an Indigenous Knowledge Custodians (IKC) and an MKO in Vygotsky's (1978) terms. In this regard, Mukwambo et al. (2014) posit that IK is the knowledge that is produced in specific historical and cultural contexts. Concurring, Nyika (2017) views IK as the knowledge that is unique to a society, that is, cultural knowledge.

As alluded to earlier some scholars add that in different areas, IK is given different labels, such as "indigenous knowledge systems", "traditional knowledge", "traditional ecological knowledge", and other related terms. In this study, I have chosen to use IK. Mosimege and Onwu (2004, p. 2) argue that IK is an "all-inclusive knowledge that covers technologies and practices that have been and are still used by indigenous and local people for existence, survival and adaptation in a variety of environments". Similarly, Dziva et al. (2011) believed that because of interacting with other knowledge systems, IK evolves and is dynamic rather than static. In other words, knowledge is not static but evolves and changes as it adapts to different cultural contexts and environments.

Despite opposing views about what IK is, there is a strengthening of the call for the integration of IK into school curricula, in particular in science classrooms (Aikenhead & Jegede, 1999; Ogunniyi & Ogawa, 2008). Taylor and Cameron (2016) refer to three perspectives of the relationship between science and IKs, namely, the inclusive perspective, the exclusive perspective and an intersecting perspective as shown in Figure 2.2 below.

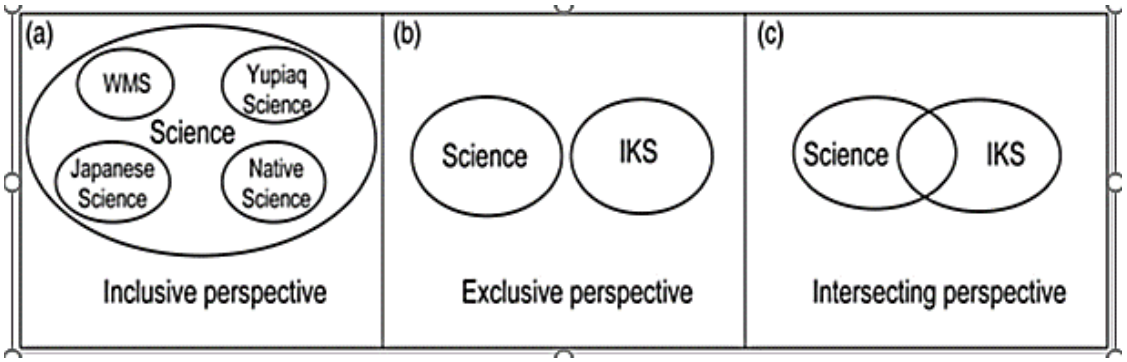


Figure 2.2: The perspectives of the relationships between science and IK systems (adapted from Taylor & Cameron, 2016, p. 36)

They further argue that "both the inclusive and exclusive views do not regard Western modern science as objective truths but recognise that all knowledge is rooted in a particular worldview with particular beliefs about the world" (p. 36). To Taylor and Cameron (2016), all three perspectives acknowledge IKs as valid and useful ways of knowing, although they see their relationships with science differently.

Moreover, these perspectives provide a framework for thinking about the place of IK in the school science curriculum. Of the three perspectives outlined by Taylor and Cameron (2016), I take the intersecting perspective and hence position myself as an integrationist in this study. That is, I am interested in the space where IK and WS overlap and complement each other.

Seehawer and Breidlid (2021) refer to this phenomenon as a dialogue between these epistemologies. It is against this backdrop that my study sought to use a Lesson Study approach when working with science teachers on how to integrate IK to mediate learning of the topics of waves and sound and redox reactions.

2.7 Community Elders and Storytelling

Community elders are people from a township who are the custodians of local knowledge (Mutanho, 2021). Interestingly, community elders are also known as Indigenous elders, holders of IK, local elders and community people (de Beer & Mentz, 2016). In this study, I used the term IKCs to refer to the custodians of the cultural heritage. I am acutely aware that they may not know the WS concepts, but I know based on how I grew up (see Section 1.3) that they possess IK and the wisdom and experience they have could be of vital importance to this study. KwaXhosa (in a Xhosa culture) they are known as *odizadala kadeb'emkhwahlaza, othambodala kade bemqongqotha* (grey hairs with insurmountable experience); some say *zizisele zenyathi* (the knowledgeable ones). Lavallee (2009) believes that IKCs are an important part of people's culture because of the prestigious role they play during cultural ceremonies. Moreover, IKCs are the MKOs (Vygotsky, 1978).

The IKCs are well respected in Xhosa culture and many instances, they serve as consultants concerning cultural beliefs and practices. Thus, tapping into the cultural heritage of IKCs in this study to mediate teaching and learning of the topics on waves and sound and redox reactions to make science relevant and accessible could be viewed as a strategic move. Drawing on Mucina (2011) in the epigraph above, Ubuntu *storytelling* is about engaging our relational selves (Seehawer, 2018), and in the context of this study, it was hoped that IKCs would impart the traditional knowledge and traditional teachings through storytelling as reiterated by Nhase and Dube (2023).

According to Mucina (2011), Ubuntu storytelling is a functional and viable teaching approach because the stories entail explanations of natural phenomena, instil morality and may at the same time provide a sense of identity as well as instruction. Concurring, Iseke (2013) posits that storytelling is a central focus of Indigenous epistemologies, pedagogies, and research approaches. Unfortunately, it seems storytelling has been marginalised by both the colonisers and the current curriculum in many South African township schools, a gap this study sought to close.

Contrary to Füller et al.'s (2008) study which concluded that community members with more knowledge and more innovative skills according to Western standards seem more willing to contribute than less qualified community members, in this study the so-called less qualified were willing to contribute. For instance, in this study, MaMcirha, one of the IKCs, shared the traditional ways of making homemade bread through practical demonstrations, visualisation and storytelling to help teachers mediate teaching and learning of redox reactions. This resonates with Mucina's (2011) conclusion that the IKCs have used the art of storytelling to extol the power of experience as a teaching tool because a story can allow a culture to generate itself. Thus, this study could contribute to cultural revitalisation as advocated by Cocks et al. (2012) and give voice, agency and recognition to the marginalised IKCs (Chilisa, 2012).

Indeed, working with community elders in this study had the potential of affording them an opportunity to contribute meaningfully to their children's education (Baquete et al., 2016; Mateus & Ngcoza, 2019). Currently, in many township schools, there is an audible cry from the school management teams (SMTs) and the teachers that there is a lack of parental involvement in the education of their children particularly in African communities. In this study, community elders were allowed to pass on IK and empower science teachers to be confident cultural brokers when integrating IK into their science lessons (Aikenhead & Jegede, 1999; Simasiku, 2022; Wyatt et al., 2017).

2.8 The Role of IK in Science Teaching

Many researchers support the integration of IK into the science curriculum (Aikenhead & Jegede, 1999; Erinosho, 2013; Ogunniyi & Ogawa, 2008; Seehawer, 2018; Shizha, 2007). Aikenhead and Jegede (1999) argue that the integration of IK has the potential to serve as a bridge between home and school science and thus promote active participation (Sedlacek & Sedova, 2017) as well as argumentation by learners (Nuntsu, 2021). This implies that the integration of IK could be beneficial to the teaching and learning of science. In this regard, Kibirige and Van Rooyen (2006) posit that science teaching is enriched when IK is used as prior knowledge in the classroom. Likewise, De Beer and Whitlock (2009) argue that by integrating IK into science classrooms, the identities of learners can be acknowledged, and thus learning might be turned into a positive experience.

In this study, it was hoped that teachers' PCK (Shulman, 1986) might be enhanced as they tapped into the cultural heritage of the IKCs. In a similar vein, Erinosho (2013) indicates that the use of IK in the classroom may increase the participation of learners as they can see the connection between everyday activities at home and what is learned in the classroom (Gwekwerere, 2016). Similarly, Nyika (2017) proffers that what learners learn from their homes or culture can be used in the classroom as the foundation for learning new concepts, thus closing the gap between the learners' worldviews and classroom experience (Aikenhead & Jegede, 1999; Tyeda, 2024).

By contrast, some scholars view the integration of IK into the curriculum as problematic (Cobern & Loving, 2001; Hodson, 2009; Horsthemke & Schafer, 2007; Southerland, 2000). These scholars warn against the assumption that anything using the label 'Indigenous' should automatically be accepted and embraced as science. Southerland (2000), for instance, is of the view that forcing all forms of knowledge about nature and naturally occurring events into the construct of science sets no boundaries for the limits of the discipline. In other words, not all cultural beliefs and practices are relevant to science (Mayana, 2020). Notably, even scholars who are proponents of IK caution against the romanticising of IK (Afonso-Nhelevilo, 2013; Keane et al., 2016; Mhakure & Otulaja, 2017; Mukwambo et al., 2014; Ogunniyi, 2007a). These scholars advise that any misconceptions embedded in IK and cultural beliefs, for example, lightning (Webb, 2013), should be identified and corrected. Thus, the relevance of employing Ogunniyi's (2007) CAT as an analytical lens in this study to harmonise IK and WS and assist me in understanding the intersection of these worldviews.

Learners should be allowed to debate such cultural beliefs and practices to minimise misconceptions and confusion (Kibirige & van Rooyen, 2006). Similarly, Webb (2013) suggests that in cases where the learners' cultural beliefs are non-scientific, teachers should show that they value such cultural beliefs by discussing them. According to Govender (2014), the exclusion of IK in the science curriculum is one of the major challenges that makes it difficult for African children to understand abstract science concepts. Thus, this study is deemed relevant and significant as it might provide an opportunity for teachers to engage in workshop discussions and document analysis and hopefully prepare them to be able to deal effectively with IK-related issues in their classrooms, specifically on the topics of waves and sound and redox reactions.

2.9 Teachers' Perspectives on the Integration of IK into Science

Ajzan (1988) posits that an attitude is a disposition to respond favourably or unfavourably to an object, person, institution, or event. Thus, teachers' perspectives towards the integration of IK in science lessons are vitally important as they are the ones responsible for the implementation. De Beer and Whitlock (2009) indicated that some teachers worry that when they integrate IK into their science lessons, they might be teaching 'pseudoscience', as they believe that IK has not been proven scientifically. Western science (WS) is still viewed by some science teachers as superior to IK as it is seen as universal and objective or 'culture-free' (Le Grange, 2007; Ogunniyi, 2007a). Shizha (2007) feels that such teachers are conservative gatekeepers who exhibit negative attitudes towards IK as they support maintaining the teaching of WS.

Another reason which could possibly contribute to the lack of integration of IK into science teaching could be the perceived conflict that exists between the worldviews of IK and WS (Botha, 2011), as claimed in Ogunniyi's (2007) CAT. He argues further that these tensions make it difficult for science teachers to integrate IK into their classrooms. In this regard, Seehawer and Breidlid (2021) are of the view that quality education needs to be responsive to students' epistemically diverse life realities (Ngcoza, 2019) and hence emphasise the importance of dialogue between IK and WS. Shizha (2007) concedes that there are differences between modern science and Indigenous science. However, he argues that the difference is not so much in the content, but in the ways of knowing and the interpretative framework that underpins such knowledge.

Ogunniyi (2007a) emphasises that teachers seem to fail to integrate IK into their lessons because they have not been trained properly since they were trained in WS. Mothwa (2011) similarly argues that there is a lack of instructional methods and PCK (Mavhunga & Rollnick, 2013; Shulman, 1986). Cronje et al. (2015) assert that IK has the potential for the conceptual development of learners in the science classroom since this cultural knowledge often serves formal curriculum concepts well. It is therefore essential to provide science teachers with the necessary skills to facilitate border crossing between the two different epistemologies (Aikenhead & Jegede, 1999; Cronje et al., 2015). Thus, this study sought to contribute towards improving the teachers' PCK by exploring how to integrate IK into science teaching, which could arguably be in the form of hands-on practical activities to enable the visualisation of science concepts.

2.10 Hands-On Practical Activities and Visualisation

According to Millar (2004), practical activities refer to any teaching and learning activity which involves the learners observing or manipulating objects and materials they are studying. In other words, learners benefit from practical activities through engagement with concepts, interactions, hands-on activities and application in science (Mayana, 2020; Shinana 2019). Asheela et al. (2021) amplify this view by arguing that hands-on practical activities are powerful in promoting conceptual development and understanding of science concepts. That is, they can enable conceptual teaching strategies as reiterated by Mavhunga and Rollnick (2013). Woodley (2009) also sees practical activities as a bridge between what learners can see and do and the scientific concepts that emerge. In my view, it should be every science teacher's vision to help learners learn science in a meaningful way.

However, some scholars have criticised the use of practical activities on the basis that many teachers tend to follow a recipe book approach in conducting practical science lessons, which in Hodson's (1990) view, brings very little learning. This is compounded because at times, the outcomes of the investigations are given in the learners' textbooks (Hodson, 1990; Simsek & Kabapinar, 2010). Despite these opposing views, however, many studies have demonstrated that involving learners (in this case, teachers) in guided practical activities motivates and encourages them to engage and ask more questions during learning (Agunbiade, 2021; Kuhlane, 2011; Liveve, 2017; Mutanho, 2021). Moreover, hands-on practical activities can be in the form of Indigenous practices (Shinana et al., 2021). In the context of this study, for instance, the expert community members used the sea as a resource and as an out-of-school context (Agunbiade, 2015) to share their IK about cultural beliefs and practices related to the sea wherein concepts on waves and sound were explored. According to Graven (2012), out-of-school contexts offer a variety of learning experiences which help strengthen the learners' positive dispositions. In addition, one of the expert community members demonstrated how she made homemade bread (Nandjedi, 2022) which provided us with an opportunity to discuss the redox reaction concepts in our PLC.

2.11 Professional Learning Communities

In 2012 the DBE in South Africa gazetted the Policy for Initial Professional Education Training (IPET) and Continuing Professional Teacher Development, which are linked to its National Development Plan. According to the DBE, the South African Council for Educators would,

through the Continuing Professional Teacher Development Management System (DBE, 2012), encourage and recognise:

- What educators do on their own to develop themselves and improve learning, and
- What educators do as part of the collective to develop themselves and improve teaching, learning, assessment, and service to the community.

Motivated by the two policies highlighted above, and the lessons that I have learned at Rhodes University in our community of practice in the science education department under the leadership of Professor Ken Ngcoza, I encouraged my colleagues (the science teachers involved in this study), that we should form our own community of practice (CoP) (Lave & Wenger, 1991; Wenger, 1998). Central to a CoP is co-learning as illustrated in Figure 2.3.

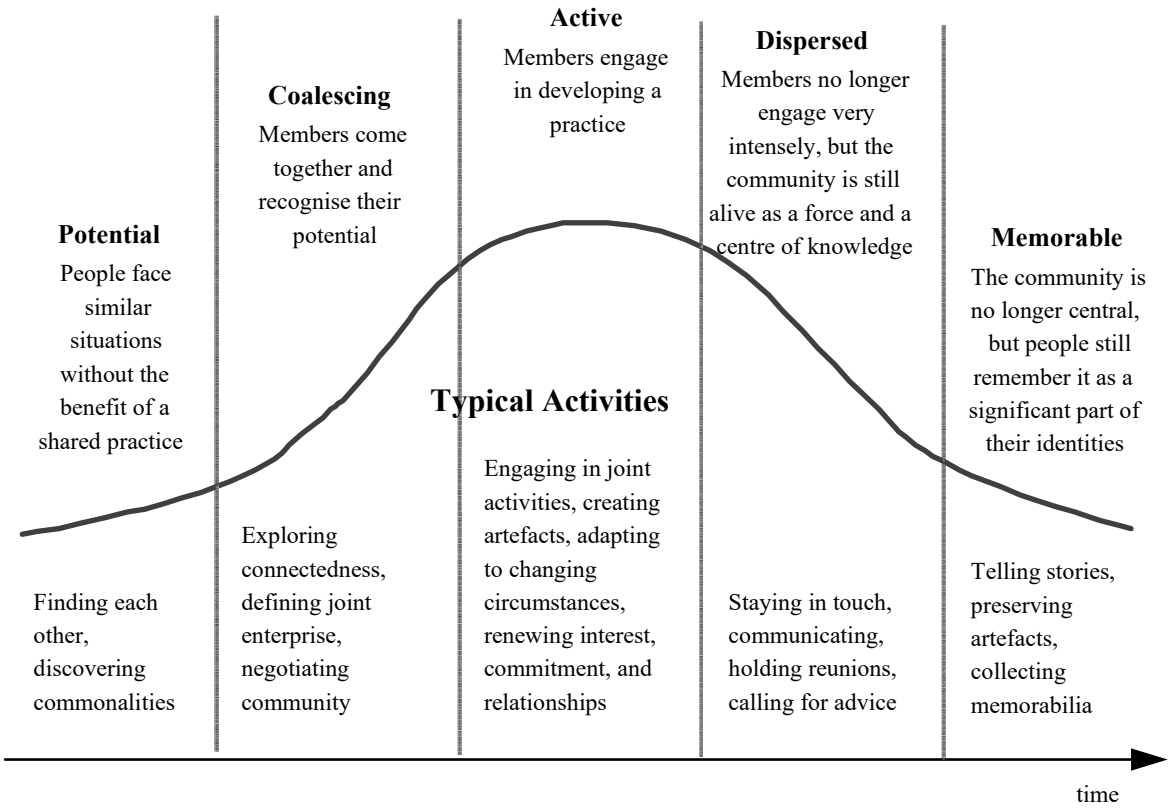


Figure 2.3: Illustration of the CoP (adapted from Wenger, 1998, p. 3)

Wenger (1998) asserts that teachers are a school's most important resource, and through the CoP or communities of practice (PLCs) individual teachers develop and share ideas and create new knowledge. In other words, PLCs help teachers develop and build their capacities within, between and beyond their individual selves (Chauraya & Brodie, 2017, Ngcoza & Southwood,

2019). Thus, at the heart of PLCs is co-learning and that resonates with the transformative learning emphasised in the Lesson Study approach.

Despite the important role teachers had to play in education as highlighted by the scholars above, in South Africa the teachers have been sidelined in policy and decision-making in education. For instance, in the curriculum changes in South Africa post 1994 the people's democratically elected government left out the teachers, particularly the township schoolteachers in crucial policy matters such as the integration of IK in teaching (CAPS, 2011). In other words, the *agency* has not been given to the agents of change (Chilisa, 2012), the teachers who are curriculum implementers (Jacobs, 2015; Ogunniyi, 2007a), a gap this study hoped to close through an effective PLC at Buyelembo Combined. In his study, Bayar (2014, p. 320) offers six key components of any effective PLC, namely:

1. must match with existing teacher needs;
2. must match with existing school needs;
3. teacher involvement in the design/planning of professional development activities;
4. active participation opportunities;
5. long-term engagement; and
6. high quality instructors.

We took a page from Bayar's (2014) copybook to establish our PLC and to achieve the purpose of this study which was to use the Lesson Study approach when working with science teachers on how to integrate IK to mediate learning of the topics on waves and sound and redox reactions in a township school. Literature reveals that teacher quality has a considerable impact on learners' learning and achievement (Bayar, 2014; Guskey, 1994; National Commission on Teaching and America's Future, 1996).

In this study, I use the term CoP which has a similar meaning to what Ngcoza and Southwood (2019, p. 1) refer to as "webs of development" or what Brodie (2013) and Chauraya and Brodie (2018) call a PLC. This resonates with Darling-Hammond's (2010, p. 35) assertion that "In the knowledge-based economy we now inhabit, the future of our country and that of an African child rest on our ability, as individuals and as PLCs in township schools, to learn much more powerfully on a wide scale."

For instance, for the past five years, my colleagues and I have been working together as a team, sharing ideas and even sharing the teaching of the curriculum. For example, in grade 12 there

are six topics, and the three Further Education and Training (FET) science teachers have agreed that each teacher would teach two topics. Each teacher has to choose two topics each year that they are going to teach, and they are supported by others. As a result, in 2020 and 2021 the school produced a 100% pass rate in Physical Sciences and also produced the best two learners in our district (who are currently studying BSc at Rhodes University and are doing very well).

Interestingly, scholars such as Ngcoza and Southwood (2015) and Ono and Ferreira (2010) are of the view that teachers' continuing professional development (CPD) is central to any educational reform as it is believed to be a way of improving teachers' knowledge of teaching and learning. The subject advisors, who are referred to as the subject specialists of the Department of Education, are expected to conduct workshops and train teachers on several topics. For instance, they should train teachers on how to plan and conduct hands-on practical activities and how to integrate IK into science teaching as recommended by the CAPS documents; unfortunately, that is not happening in spite of the calls from scholars such as Feiman-Nemser (2001) who believe that a well-designed PLC programme serves to broaden and extend teachers' subject matter knowledge and refine their PCK.

The emergence of Covid-19 and budget constraints have made matters even worse in terms of teacher support and CPD, and that has left teachers in the cold and on their own. Thus, to me, this study is timely and might be ideal for rekindling teachers' PLCs (Brodie, 2013; Chauraya & Brodie, 2018). Hopefully, the findings of this study could be used as a catalyst for whole school development and help sustain and improve the academic excellence of the school from the lower to the higher grades. Notably, at the core of any PLC is collaborative learning as indicated by the second policy mentioned above, and it resonates well with the Ubuntu research approach that will be used in this study.

In this study, our PLC consisted of six science teachers from a township school, five IKCs, one critical friend (a language teacher), three university lecturers, a headmaster from Zambia and me (a science teacher as well). Five of these teachers, a critical friend (isiXhosa and English language teacher), IKCs and I are isiXhosa speakers, and one teacher is from Cameroon. Hence, our PLC is heterogeneous, and we acknowledge that diversity is a strength rather than a weakness.

The science teachers were actively involved in the co-planning and implementation of the transformative professional activities (document analysis, workshops and group discussions, co-development of lessons and journal reflections) as emphasised by Ngcoza (2007). The IKCs presented to the teachers related to the two topics of interest in this study. It was hoped that the teachers' subject matter knowledge (SMK) and PCK (Shulman, 1987) might be affected positively. It is recognised, however, that science teachers need a balanced view of IK and science in order to enrich their SMK and PCK.

2.12 Chapter Summary

This chapter reviewed literature relevant to this study. It explored the nature of IK, the nature of WS and highlighted the benefits of integrating the two knowledge systems. Furthermore, IK was discussed at great length, and the relevance of IKCs and storytelling in this study was considered. The role of IK in science teaching and Ogunniyi's CAT as an analytical lens during our interactions and argumentations. I discussed the teachers' perspectives as well as challenges that science teachers experienced in their attempts to integrate IK into their science teaching. The literature review also looked at hands-on practical activities and visualisation and because I will be working with science teachers, professional learning communities. In the next chapter, I will discuss the theoretical frameworks of the study.

CHAPTER THREE: THEORETICAL FRAMEWORKS

> It is through theory that researchers formulate and find causal relationships and that theory helps to predict and guide the direction of the research, identifying key fields, methods of working, key concepts and therefore serving as a basis for action. (Cohen et al., 2018, p. 71)

3.1 Introduction

The previous chapter looked at literature relevant to the study. This chapter discusses the theoretical frameworks that underpinned the study, namely, Vygotsky's (1978) sociocultural theory (SCT) in conjunction with Shulman's Pedagogical content knowledge (PCK), and Ogunniyi's Contiguity Argumentation Theory (CAT).

Theoretical frameworks are structures that influence, hold and support research (Abend, 2008). A theoretical framework introduces and describes the theory that explains why the research problem under study exists. Hence, a theoretical framework is a vital component of any study, informing the research process. Merriam (2009) adds that a theoretical framework stimulates and shapes every single aspect of research. As alluded to earlier I used Vygotsky's SCT, Shulman's PCK, and Ogunniyi's CAT as my theoretical frameworks. Because of the nature of this study, these theoretical frameworks were used as complementary lenses from which I drew the language of description and the tools of analysis.

The following sections briefly discuss the three theories. Each section starts with a brief description of the theoretical framework before explaining its relevance to this study. Finally, I briefly explain how the three theoretical frameworks complement each other in this study.

3.2 Vygotsky's Sociocultural Theory

The sociocultural theory (SCT) is based on the link between social interactions and human development (Vygotsky, 1978). To Vygotsky (1978), everything is learned on two levels: firstly, through interaction with others (interpsychological level), and then integrated into the individual's mental structure (intrapsychological level). The SCT views learning as a socially mediated process in which learners construct their own understanding of phenomena through

interactions with their peers and MKO, usually the teachers. However, in the context of this study, the community members or the IKC are regarded as the MKO. This adds to the new knowledge in the study. The social constructivist perspective on learning which is part of SCT highlights the role of active involvement in tasks associated with making connections between experience and prior knowledge (McRobbie & Tobin, 1997).

Although Vygotsky's SCT focused on how children learn, the nature of this study is to promote teacher learning and teacher development through interactions with each other, using a Lesson Study approach and interacting with the expert community members. Since the community members are the custodians of IK, they are regarded in this study as the MKOs. It was hoped that the interactive discussions, presentations, document analysis and co-designing of exemplar lessons, might help advance the teachers' knowledge and understanding of how to integrate IK into their teaching. I also hoped that the study might assist science teachers to make informed decisions and make science accessible and relevant to the township learners (Gwekwerere, 2016). Within SCT I used the following concepts: mediation of learning, culture and language, social interactions, the zone of proximal development and scaffolding.

3.2.1 Mediation of learning

Vygotsky (1978) views mediation as a tool used in cognitive change. In other words, mediation is a pedagogical technique that may be used by a teacher to help a learner move to the next level of understanding. In this study, however, it was observed that storytelling (see Section 2.7) was used, and isiXhosa was used by IKCs to enable the learning process as well as social interactions. This contributes to new knowledge in the study. I also observed the interactions among the teachers when they engaged in document analysis and co-developed exemplar lessons that integrated IK and hands-on practical activities (Asheela et al., 2021; Shinana et al., 2021). I also observed how the teachers enacted these as mediating tools to aid the teaching and learning of the topics of waves and sound and redox reactions. Furthermore, it was hoped that the use of reflective journals by the teachers might influence the teachers' zone of proximal development (ZPD). Mediation of learning is the connection between the existing state of mental development and the ZPD (Stott, 2016). According to Vygotsky (1978), mediation involves the use of tools such as language, culture, and materials to achieve the goal of learning.

3.2.2 Culture and language

Chilisa (2012) posits that language expresses the patterns and structures of culture. She further argues that language influences the way we think and behave and how we view things. In this study I observed the interactions and engagements between the teachers and the expert community members, paying particular attention to the use of language, in particular isiXhosa, as a cultural tool. According to Vygotsky (1978), language plays a crucial role in fostering learning. Smith et al. (2017) view culture as a body of knowledge that people have in a particular society. This body of knowledge includes knowledge about ways of living, knowledge about places and the environment, cultural artefacts and symbols, prior everyday knowledge and Indigenous language.

Likewise, Chilisa (2012) explains that culture is lived, and language, through all its manifestations, reflects that life, giving it form and texture. Vygotsky (1978) reveals that language plays a crucial role in teaching and learning. In this study, I observed the use of language (isiXhosa and English) and cultural practices during the presentations by the expert community members. Sedlacek and Sedova (2017) posit that there is a close link between speaking and learning. Furthermore, Vygotsky (1978) argues that learning and cognitive development are culturally and socially based. This means learning is promoted by social interactions.

3.2.3 Social interactions

Learning is a social process in which learners acquire knowledge through interacting with their peers and the MKOs (Vygotsky, 1978). Accordingly, Vygotsky (1978) contends that social interactions and language play crucial roles during the learning process. In other words, to Vygotsky (1978), social interactions are the basis of learning and development. Moreover, for development to occur, learning should take place first. Concurring, Sedlacek and Sedova (2017) argue that learners construct their own understanding of phenomena through active participation in their environment. In the context of my study, teachers from a township school interacted at the sea (out-of-school context) with the expert community members who were regarded as MKOs who shared their knowledge, experiences, and cultural beliefs about the sea.

Social interactions and engagements provided a multitude of learning opportunities for the teachers, which could have positive effects on the teaching and learning of the topic of waves and sound. Similarly, the interactions between the teachers and the expert community members

who shared their Indigenous ways of making homemade bread could potentially help the teachers develop their PCK on the topic of redox reactions. This in turn could help the teachers contextualise the lessons on redox reactions and other topics, which could ultimately be beneficial for the learners. Essentially, this study sought to explore the use of a Lesson Study approach (Fernandez, 2002) when working with science teachers on how to integrate IK to mediate learning on the topics of waves, sound and redox reactions.

3.2.4 Zone of proximal development

Vygotsky (1978) defines the zone of proximal development (ZPD) as the distance between the actual development level as determined by independent problem-solving and the level of potential development as determined through problem-solving in collaboration with the MKO. In other words, the actual development level is a stage in which a learner (in the context of this study, a teacher) can do things on their own, and the potential development level is a stage which is beyond the actual development stage, in which the support of a more capable person or artefacts is required. Simply put, the ZPD exists in a space between the actual development and the potential development, which means the possibility for learning occurs once the ZPD comes into existence.

Stott (2016) views ZPD as a continuum between what the learner already knows and that which they may potentially know with the assistance of the MKO. In this study, the ZPD concept was used as a learning space between the teachers' present PCK and their potential PCK (in terms of their understanding of IK and its integration into science lessons) with the help of the community members (MKOs). In addition, it was hoped that as the teachers interacted and engaged in the collaborative activity of document analysis and co-development of exemplar lessons during the workshops, the opportunity for learning and professional development might present itself (Stott, 2016). This kind of ZPD, according to Stott (2016), has a two-way character and perhaps suggests a less restricted notion as each partner possesses some knowledge and skills but requires another person's contribution to make progress.

Extending on Vygotsky's seminal work, Wood et al. (1976) used the metaphor of *scaffolding* to describe the role of the parents (MKOs) in helping children to develop new insights into what they are learning. This should be tactfully done by gradually transferring responsibility to them so that they can complete the tasks on their own. For instance, at some point in this study, I helped MaMpehle, a Foundation Phase teacher during the hands-on practical activities

until she was comfortable working on her own. This resonates with Rojas-Drummond et al.'s (2013) view that for scaffolding to be effective, the support of the MKO should diminish as the novice learners' responsibility and control increases. In other words, as the learners gain more control of what they are learning, the MKO must gradually hand over the learning process to the learners.

Brunner (1969) averred that, as part of cognitive scaffolding, learners will transition through three stages based on action, images, and symbols as well as language. In this study, this was depicted during the IKCs' practical demonstration of how to make *isonka samanzi* (homemade bread). Furthermore, in this study, scaffolding was indeed used during the capacity-building workshops as a special type of teaching approach to empower the science teachers to close the gaps identified during the pre-intervention sharing discussions. The ultimate intention of scaffolding is to empower learners (science teachers in the context of this study) to take charge of teaching and learning.

It was my belief that the SCT might serve as an ideal lens for analysing the data of the lessons that integrate IK by linking words, phrases and statements to social interactions, culture and language, mediation, the ZPD and scaffolding.

3.3 Pedagogical Content Knowledge

Pedagogical content knowledge (PCK) is a theory that was introduced by Shulman (1986). For teachers to be able to teach in a way that will help the learners understand, teachers should possess what he referred to as PCK (Shulman, 1986). According to Carlson and Daehler (2019), teachers' PCK is developed, shaped and refined over time through formal education, teaching experience and professional sharing. In this study, six science teachers and I (and a language teacher, as a critical friend) constituted a PLC, wherein we shared ideas and experiences as we navigated our way towards how to integrate IK when teaching science.

For that reason, teachers should have a good conceptual and contextual understanding of the topic they teach before they teach it (Yusof et al., 2012). In other words, the teachers' knowledge needs to be transformed in a way that makes it easier for the learner to understand (Shulman, 1987). Concurring, Yusof et al. (2012) argue that teachers are not only required to be capable of conveying information, but they should be able to explain and link science to real-life situations (Gwekwerere, 2016) and other subject content.

3.3.1 Topic-specific pedagogical content knowledge

Shulman's theory has been criticised by some scholars. For instance, Kind (2009) argues that PCK is not backed by theoretical evidence to support its existence and that it is not explicit knowledge that can be easily identified, classified, and taught to trainee teachers. Mavhunga and Rollnick (2013) assert that lessons must be taught in a manner that is easy to comprehend by the learners, but these scholars argue that not all topics can be taught in the same way and hence PCK is topic specific. In that regard, Mavhunga and Rollnick (2013) adapted the five content-specific components of the TSPCK used in Geddis and Wood (1997, p. 623) as shown in Figure 3.1 below to explain that teachers cannot use the same method to teach different topics and subjects.

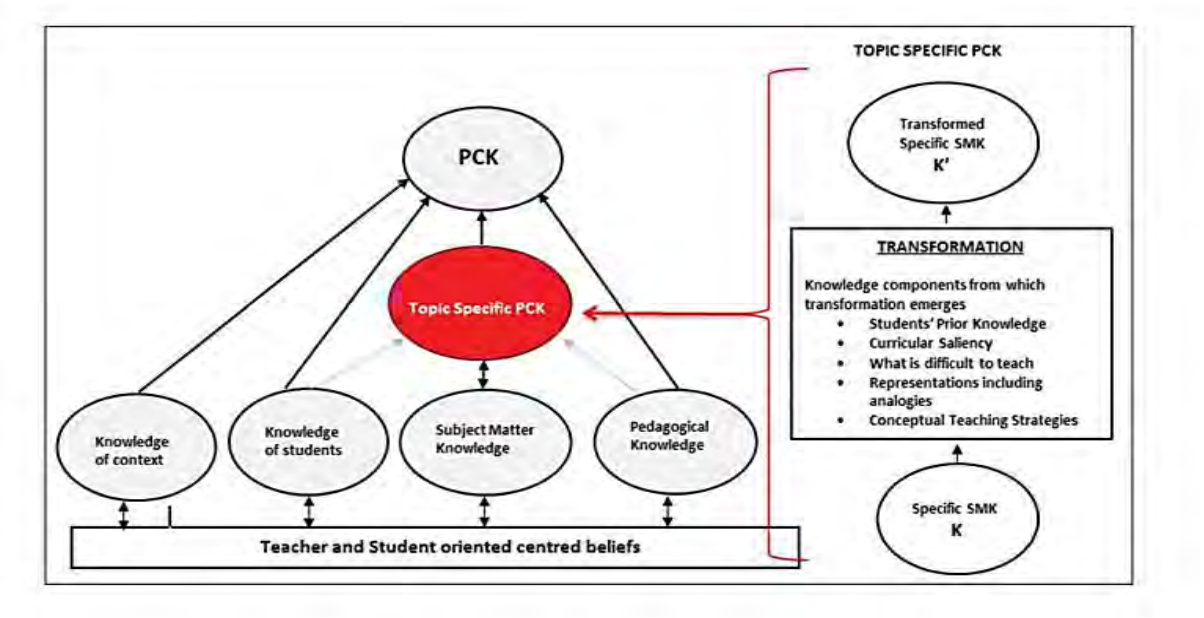


Figure 3.1: Showing the five components of TSPCK (adapted from Mavhunga & Rollnick, 2013, p. 115)

Figure 3.1 above shows the five TSPCK components that expert teachers use to transform the SMK of a specific topic in a way which is understandable to learners at a given level and context (Mavhunga & Rollnick, 2013). In this study, a Lesson Study approach was explored to assist the transformation of knowledge required. This transformation required the use of the following TSPCK components:

- *Learners' prior knowledge* includes common learner misconceptions, alternative conceptions, and the correct knowledge that learners have about the content. Basically, PCK is transformed from SMK by five knowledge components indicated in Figure 3.2. Thus,

improving teachers' PCK is the primary focus of my study. I would add that learners' prior knowledge includes their IK.

- *Curriculum saliency* refers to the identification of the most important concepts and logical sequencing of a topic, without which understanding of the topic would be difficult for the learners.
- *What makes the topic easy or difficult to understand* includes the identification of gatekeeping concepts in a topic that is difficult to understand and that requires a particular approach so that learners can comprehend concepts.
- *Representations* include the use of examples, illustrations, analogies, simulations and models that may be employed to support an explanation.
- The *conceptual teaching strategies* refer to the effective teaching strategies derived from the considerations of learner misconception if there are any areas of difficulty or known areas of importance of a concept.

In this study, the TSPCK components (Learners' prior knowledge; Curriculum saliency; What makes the topic easy or difficult to understand; Representations; and Conceptual teaching strategies) were used to analyse the curriculum documents (see Appendix F). Professional development programmes, in the form of workshops and presentations, aimed at improving the PCK of teachers, were arranged.

Even though several scholars have agreed that Shulman's theory was a breakthrough in trying to understand the knowledge base that teachers use to break down and simplify subject matter to make it easily understood by learners, critics have argued that it has no theoretical basis to back it up (Kind, 2009). This has led the proponents of PCK to embark on studies to develop it further and gave birth to what they referred to as a revised consensus model.

3.3.2 The revised consensus model

In 2012 PCK was refined by a group of scholars for a common understanding of PCK, and a new Consensus Model of PCK was agreed upon which was referred to as Teacher Professional Knowledge (Gess-Newsome, 2015). Shinana (2019) refers to this as the knowledge base for planning a lesson and the actual teaching of the lesson. However, the Consensus Model of PCK was found to have limitations since it did not emphasise teaching strategies when applied in a classroom situation.

This has led its proponents to embark on studies to develop it further. For instance, in 2012 in Colorado Springs a group of scholars met to create an agreed model which came to be known as the Teacher Professional Knowledge Model (Consensus PCK Model) (Gess-Newsome, 2015, p. 31) which would help them to have a common understanding of PCK. The agreed model is illustrated in Figure 3.2 below.

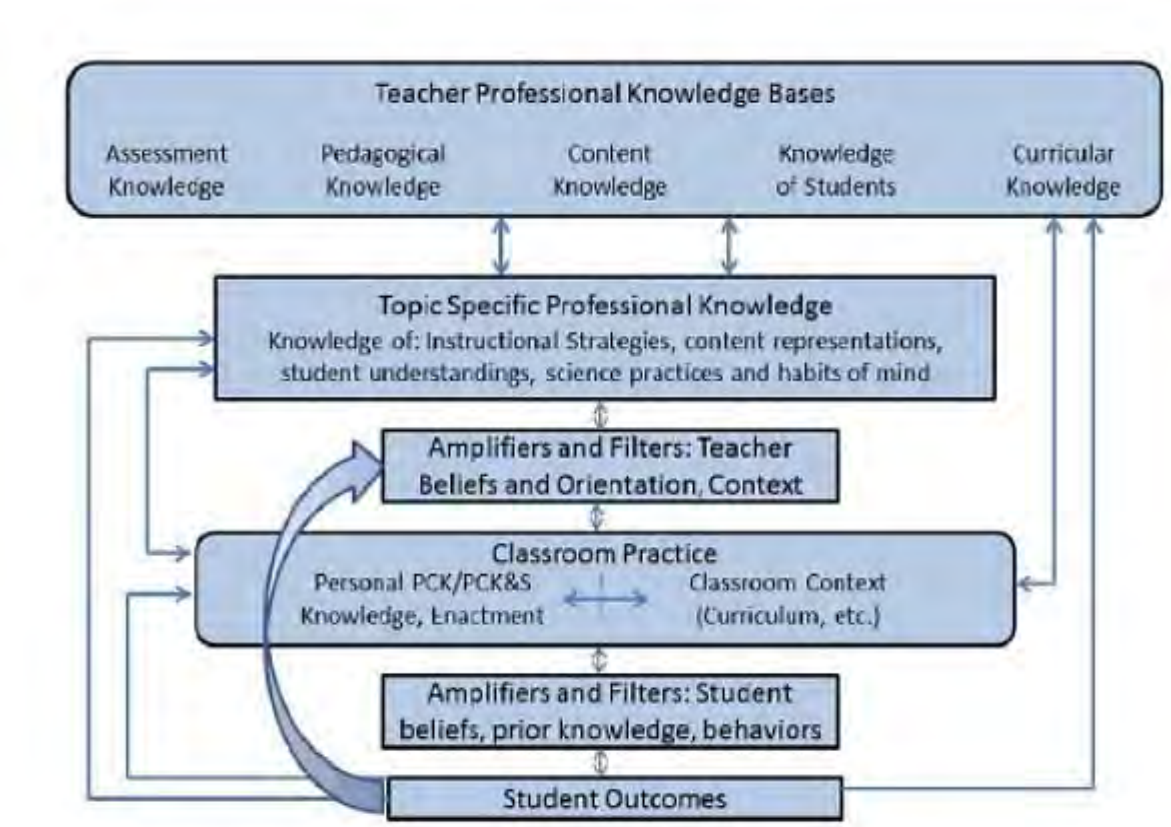


Figure 3.2: Consensus Model of PCK from PCK Summit 2012 (Gess-Newsome, 2015, p. 31)

This model shows us that a teacher has a broad professional knowledge base from which to draw insights. Their PCK is multi-layered. It consists of both the knowledge of the subject matter, the learners, and the context within which the teaching-learning process is taking place. Accordingly, Shinana (2019) saw it as the knowledge base for planning a lesson and the actual teaching of the lesson. Subsequently, to rectify these limitations, the new model was further refined to reflect the multi-dimensional nature of PCK (Carlson & Daehler, 2019). What was modified was the nature of PCK, for instance, the new RCM of PCK categorises PCK into three realms, namely, collective PCK (cPCK), the personal PCK (pPCK), and the enacted PCK (ePCK). Presented below in Figure 3.3 is the new RCM of PCK which shows the three layers of PCK as the cPCK, the pPCK, and the ePCK (Carlson & Daehler, 2019).

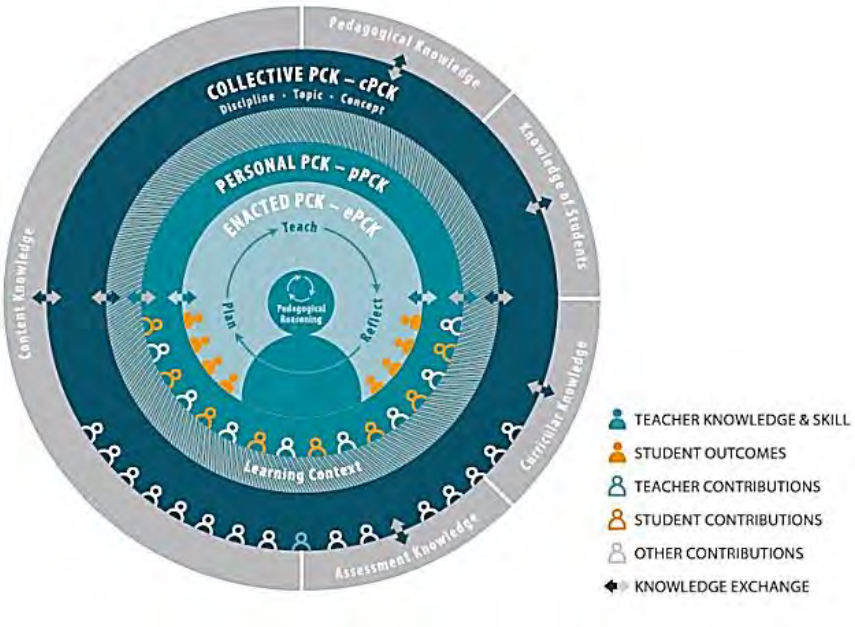


Figure 3.3: RCM of PCK (Carlson & Daehler, 2019, p. 83)

The RCM of PCK shows that there are three realms of PCK, namely, collective PCK, personalised PCK or planned PCK, and the enacted PCK. Mavhunga (2019) explains that collective PCK is the knowledge of teaching that teachers develop from initial teacher training, textbooks and other sources that are available to them. Mavhunga (2019) elaborates that this realm of PCK is developed through formal courses where public and published knowledge on PCK is discussed.

The next realm, the personalised PCK develops from collective PCK and is influenced by individual teachers' personal beliefs, contextual and other factors that are unique to the teacher. From this personalised PCK emerges the actual classroom pedagogical practices, known as the enacted PCK (Mavhunga, 2019; Mazibe et al., 2020). The workshops conducted in this study explored how teachers develop a collective PCK. Mavhunga and Rollnick's (2013) five components were used as I observed the teachers' teaching to see whether the intervention had shifted the teachers' understanding of how to integrate IK into science lessons. In this study three categories of PCK were deemed relevant and essential since the teachers were engaged in collaborative and individual activities to enhance both their collective and individual abilities to integrate IK into science teaching, with the goal of transforming their enactment PCK.

In line with Cohen et al.'s (2018) belief that theory helps researchers to select, classify and organise ideas, processes and concepts from the research, the two theories (SCT and PCK) were deemed appropriate for this study as they complement each other very well. The SCT is a learning theory which is normally used for learners. However, in the context of my study, teachers are the learners, learning how to integrate IK into science lessons. To be able to achieve this, PCK theory was required. For instance, PCK and in particular the five TSPCK components were taken into consideration; prior knowledge was drawn upon and representations took the form of Indigenous practices, for example, *isonka samanzi* (homemade bread) and traditional music. These enabled teachers to deal with what is difficult to teach.

So, PCK (specifically, the components of TSPCK) were employed in this study to analyse ideas that emerged from social interactions (Vygotsky, 1978) and better understand the science teachers' reflections and how their ZPD shifted during the study. However, the two theories (SCT and PCK) do not seem to address research from an African perspective. Hence, I augmented the two theories with Ogunniyi's CAT.

3.4 Contiguity Argumentation Theory

Contiguity Argumentation Theory (CAT) is a learning theory which dates to the Platonic and Aristotelian eras (Ogunniyi, 2007a; Ogunniyi & Hewson, 2008; Ogunniyi, 2018). The CAT can be applied to harmonise two distinct worldviews such as WS and IK (Ogunniyi, 2007a). Accordingly, CAT takes cognisance of the fact that learners have different worldviews concerning scientific phenomena. Moreover, CAT incorporates non-rational (spiritual) and cultural knowledge such as cultural practices related to the sea and how to make *isonka samanzi* (homemade bread) within its framework. The CAT was deemed appropriate in this study as it might provide a platform to analyse the teachers' engagements and arguments during our PLC activities. Within CAT, I drew on the five categories of cognitive states, viz. *dominant, suppressed, assimilated, emergent* and *equipollent* as my lenses.

Ogunniyi (2007b) and Hewson and Ogunniyi (2011) see the five categories mentioned above as describing the way conceptions move within a learner's (in the context of this study the teacher's) mind and can also describe the movement of conceptions among teachers involved in a dialogue warranting the mobilisation of scientific and/or IK-based conceptions. For instance:

- **Dominant** – a powerful idea that explains and predicts facts and events effectively.

- **Suppressed** – an idea becomes suppressed in the face of more valid evidence.
- **Assimilated** – a less powerful idea might collapse into a more powerful one in terms of the persuasiveness of the dominant idea to a given context.
- **Emergent** – there may be circumstances where no prior knowledge exists, and new knowledge has to be acquired or developed.
- **Equipollent** – when two competing ideas have comparably equal intellectual force, the ideas tend to co-exist without necessarily resulting in a conflict (Govender, 2017; Ogunniyi & Hewson, 2008).

It was hoped that the five categories of CAT mentioned above might help promote the teachers' arguments during interactions with the expert community members on the integration of IK in science and document analysis as was the case with Nuntsu's (2021) study. In my view, the five categories of CAT cohere with the SCT components very well in this study. For example, when learners' IK is suppressed, this might affect their ZPD in terms of conceptual understanding. By contrast, social interactions and argumentation could be enhanced when both WS and IK co-exist (equipollent cognitive state) and this is akin to Jegede's (1999) collateral learning.

Accordingly, the three theories complemented each other well in this study. For instance, the SCT is a learning theory, and we were interested in the learning process. It provided the overarching theoretical framework upon which this study was anchored since social interactions were at the heart of this study and the IKCs were regarded in this study as the MKOs. It was used to understand the Indigenous people's cultural practices and how they could be used to integrate IK during science learning. Because we were also interested in the teaching practice of the science teachers, we complemented the SCT with PCK which is a teaching theory. Particularly Mavhunga and Rollnick's (2013) TSPCK was used to analyse data. The CAT provided an extra theoretical lens to develop and understand the lessons co-designed by the teachers in this study. Furthermore, the five categories of CAT were used to analyse teachers' arguments during interactions with the IKCs on the integration of IK into science and during document analysis.

Neither SCT nor PCK/TSPCK explain the disparities between thought systems (IK and WS) however CAT does this. For that reason, CAT was deemed necessary in this study, and it also complemented the two theories well as it created harmony between the two different world views, IK and WS in this study. Figure 3.4 below shows the intersection of the three theories.

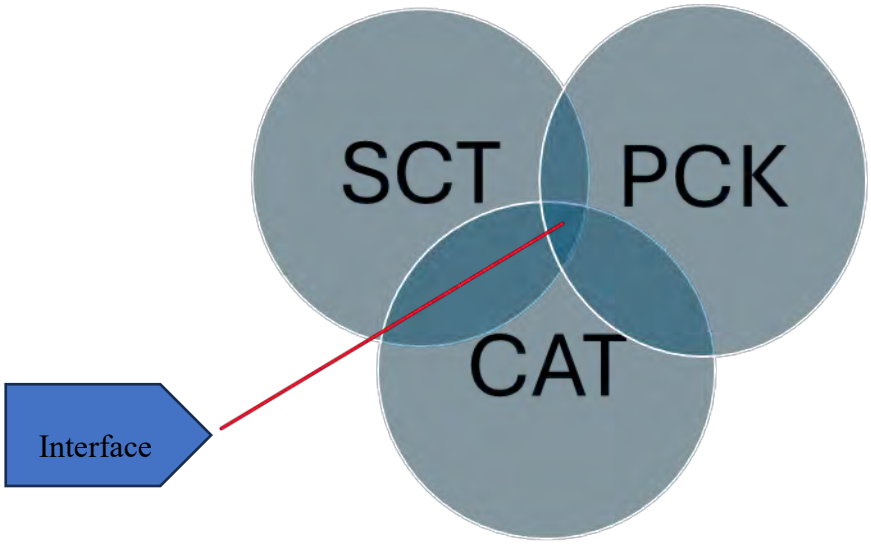


Figure 3.4: The interface of the three complementary theories used in this study

The SCT provided the overarching theoretical framework upon which this study was grounded while the PCK and the CAT provided the methodological and analytical tools that were used in this study.

3.5 Chapter Summary

In summary, in this study, the three theories were deemed relevant as they complemented each other very well. For instance, Vygotsky's SCT is appropriate to this study because it is a learning theory. However, its focus is on children (learners) whereas learners in this context are science teachers. Therefore, I complemented it with Shulman's (1986) PCK which is a teaching theory. Central to PCK is the transformation of knowledge so that it is comprehensible to learners and might thereby shift their ZPDs (Vygotsky, 1978). In that regard, PCK/ TSPCK provides a theoretical framework for examining and understanding teachers' skills (Kind, 2009). I augmented the SCT and PCK with Ogunniyi's CAT which helped to harmonise IK and WS. In the next chapter, I will discuss the design of the research.

CHAPTER FOUR: RESEARCH METHODOLOGY

> The transformative research paradigm is characterised as placing central importance on the lives and experiences of marginalised groups, such as women, ethnic/racial minorities, people with disabilities, and those who are poor. (Mertens, 1999, p. 4)

4.1 Introduction

The previous chapter looked at the theoretical frameworks that informed this study. This chapter outlines the research methodology that was followed in conducting this study. Creswell and Creswell (2018) view a research methodology as a plan that a researcher will use to systematically collect and analyse the data required to answer the research question. The main goal of this study was to leverage the use of a Lesson Study approach when working with science teachers on how to integrate IK to mediate learning of the topics of waves and sound and redox reactions in a township school.

In this chapter, I discuss and justify the research paradigms underpinning the study, followed by the research design employed, sampling procedures, data-gathering methods, data presentation and analysis as well as the validity and trustworthiness and ethical considerations.

4.2 Research Paradigms

According to Lincoln and Guba (1985), a paradigm serves as the lens or set of organising principles by which reality is interpreted. Likewise, Cohen et al. (2018) explain that a research paradigm represents a particular worldview that defines, for the researcher who holds this view, what is acceptable to research and how this should be done. In a similar vein, Creswell (2014) posits that a research paradigm is a lens through which a researcher distinguishes worldviews. Also, a research paradigm is made up of four entities: ontology, epistemology, axiology and methodology (Wilson, 2008). Expanding further on this worldview, Scotland (2012) elaborates that ontological assumptions are our understanding of what constitutes reality, epistemological assumptions are how knowledge is acquired, and axiological assumptions are the values

underpinning a research study. This study was underpinned by two complementary paradigms, namely, the indigenous research and the transformative paradigms (Chilisa, 2012).

While the indigenous research paradigm enabled me to understand and appreciate the Indigenous participants' culture and practices, the transformative paradigm enabled the IKCs and the science teachers to work in harmony as a family. Within the indigenous research paradigm, Ubuntu was the relational perspective that informed the researcher-participant relationships in this study and assisted in the navigation of power dynamics. This is explained in Section 4.2.1 in the first paragraph. Each of these is discussed below.

4.2.1 Indigenous research paradigm

In this study, I researched *with* the science teachers and the IKCs rather than *on* them as reiterated by Ngcoza and Southwood (2015). Initially, I considered using an interpretivist paradigm which seeks to describe and understand how people make sense of the contexts in which they live and work (Maree, 2014). I thought that the nature of an interpretivist paradigm would enable me to make a descriptive analysis of the science teachers' responses during the semi-structured discussions in phase one of the study. However, one of the criticisms of the interpretivist paradigm is that it tends to rely on descriptions of individuals at the expense of descriptions. It is acknowledged, however, that within the indigenous research and transformative paradigms there are elements of the interpretive paradigm. This is also evidenced by my research question 1.

Moreover, in this study, we used sharing circles instead, so I deemed it appropriate to use an indigenous research paradigm (Chilisa, 2012), focusing on the Ubuntu perspective since IK and cultural practices were used to mediate learning in this study (Botha, 2011). Essentially, the indigenous research paradigm allowed me to appreciate the Indigenous participants' cultures and practices.

Secondly, I thought it would be fitting to look for a paradigm that would shed some light on axiological issues that underpinned this study. In this regard, Wilson (2008) views the indigenous research paradigm as a circle consisting of the four entities mentioned above, as opposed to the Western research design which prefers to treat the four entities as separate elements. Concurring, Chilisa (2012) indicates that the indigenous research paradigm emphasises the interconnectedness of all things.

In addition, the indigenous research paradigm is about respecting other ways of knowing such as IK and respecting and acknowledging community members' cultural heritage and giving *voice* to them (Chilisa, 2012; Lavallee, 2009; Mateus & Ngcoza, 2019). The axiological assumptions in this study are embedded in the section that talks about values and ethical considerations. Also, I assumed that in this study we might be confronted by the dilemma of what Breidlid (2009, p.144) referred to as "crossing epistemological borders", which led him to ask the question "How do pupils and even teachers cope with a knowledge system in school which is alien to their home universe?" (Breidlid, 2009, p. 144). Within the indigenous research paradigm, I employed the Ubuntu perspective.

Ubuntu comprises "philosophical assumptions about the nature of social reality (*ontology*), ways of knowing (*epistemology*), and ethics and value systems (*axiology*)" (Chilisa, 2012, p. 20) (my emphasis). Concurring, Seehawer (2018) avers that Ubuntu is an African philosophy, worldview, moral ethics and a way of knowing. Ubuntu is a concept that exists in many African cultures (Khupe, 2014; Ogunniyi, 2018). In South Africa, for instance, Ubuntu is known as '*vhuthu*' in Venda, '*botho*' in Sotho and '*Ubuntu*' in isiXhosa, which means being human, humble, polite, caring and loving. As alluded to earlier, I grew up in Makhanda, a small town in the Eastern Cape, South Africa where I lived and experienced Ubuntu at its best (see Section 1.3). As young people in the township, we were raised by the community, and we were taught to respect elders and respect one another. The expression that says "*umntu ngumntu ngabantu"* which literally means "we need each other" was the language of the day. My mother used to say "*Mbi umntu ongamaziyo umntu, mntwanam*" (My child it is bad for some not to respect and care for other people) – to me, this is the essence of Ubuntu, wherein, you show value, respect, care, kindness, tenderness, cooperation, love, support and encouragement when dealing with people.

I chose to use Ubuntu as a perspective in this study because I believed Ubuntu might help me establish the much-needed trust in the African culture and respect, cooperation and free interaction with my fellow participants, as opposed to working *on* my participants as cautioned by Ngcoza and Southwood (2015). Furthermore, I believed that Ubuntu and the transformative paradigm might help me navigate the slippery path of positionality that might arise during the research process.

4.2.2 Transformative paradigm

At first in this study, I considered using a critical paradigm which seeks to address issues of social justice and marginalisation by embracing the emancipation function of knowledge (Scotland, 2012). Horkheimer (1982) argued that the critical paradigm seeks to emancipate and liberate the participants from circumstances that have enslaved them. Agreeing, Scotland (2012) describes the critical paradigm as a tool of emancipation. However, I realised that in the context of this study, I needed a paradigm that focused more on transformative learning and at the same time had emancipatory components (Sannino et al., 2016), thus, I opted for the transformative paradigm.

It is this transformative learning nature of the transformative paradigm that resonated more with the main goal of my study which sought to leverage the use of a Lesson Study approach when working *with* science teachers on how to integrate IK to mediate learning of the topics on waves and sound and redox reactions as examples. My research involved IKCs who were more knowledgeable (Vygotsky, 1998) about cultural beliefs and Indigenous practices related to the sea and how to make homemade bread using ancient Indigenous techniques.

In turn, this knowledge was used by the science teachers involved in this study to mediate the teaching and learning of the two topics mentioned earlier. In other words, the transformative research paradigm enabled the IKCs and the science teachers to work in harmony as a family (Chilisa, 2012). Resultantly, transformative learning took place. It could be argued that an empowering environment was created for the science teachers to become cultural knowledge brokers (Simasiku, 2022; Wyatt et al., 2017) and their PCK in terms of the understanding of IK improved during the social interactions with IKCs. According to Mertens (1999), the transformative paradigm is based on key epistemological, ontological, axiological and methodological assumptions that are different from those underlying postpositivist and constructivist assumptions.

4.2.2.1 Epistemology in the transformative paradigm

Critical in this epistemology is that "in order to achieve an understanding of what is valid knowledge, this epistemological assumption is characterised by a close collaboration between researchers and participants of the study" (Mertens, 2010, p. 13). In other words, I had to make sure that a trusting relationship between our PLC and IKCs was established by clarifying each person's role and how the study was going to be conducted. In this study, the science teachers

and I positioned ourselves as co-learners and we used the Ubuntu approach to explain to the IKCs that we were not clear about IK-related waves and sound and redox reactions, and that we were not confident about integrating IK into our science lessons. That led to rich discussions of issues related to cultural practices and beliefs concerning the sea and homemade bread; as a result, we learned a lot from the presentations by the IKCs. This approach had a direct influence on the methodological assumptions used in this paradigm.

4.2.2.2 Ontology in the transformative paradigm

Taylor and Cameron (2016) proffered that one of the iniquities of the apartheid regime was the suppression of Indigenous African ontology and epistemology in the South African schooling system. Ontological assumptions are assumptions about what constitutes reality. Illuminating, Chilisa (2012) explains that "ontology in transformative paradigm has to do with social reality that is historically and constantly changing depending on social, political, cultural and power of communities" (p. 46).

Such a change was observed in this study during the demonstration of how to make *isonka samanzi* (homemade bread) using traditional methods by one of the IKCs when some of the female teachers indicated that they bought the dough from the supermarket. This is contrary to the traditional cultural practice where women used to make their own dough with pride. Also, traditionally, men showed no keen interest in cooking as this was a job reserved for women. Thus, the cultural practices of indigenous people are changing due to the Western ways of doing things. In this regard, it could be argued that other ways of knowing are integrated into IK. Resultantly, this has axiological implications.

4.2.2.3 Axiology in the transformative paradigm

Axiology is the branch of philosophy that is concerned with ethics. Ethical considerations include respect for cultural norms of interaction and the promotion of human dignity (Mertens, 2010). In this study, traditional protocols were observed and given the dignity they deserved. Furthermore, the transformative paradigm rejects cultural relativism and the notion that there is a single reality but rather assumes that multiple realities are shaped by social, political, cultural, spiritual, gender and other values (Mertens, 2010). In this study, both the PLC and IKCs consisted of males and females. We made sure that everyone was treated with respect, especially females who were pushed to the margins by the apartheid regime and still today by traditional stereotypes. This had a direct link to the epistemological assumptions.

4.2.2.4 Methodology in the transformative paradigm

The epistemology outlined above paved the way for the development of a clear research purpose, design and data-gathering techniques that were culturally appropriate (Martens, 2010). Also, Mertens (2010) argued that the transformative paradigm might use quantitative, qualitative, or mixed methods and emphasised the importance of involving IKCs in methodological decisions. For instance, we hoped that the Sangoma, one of the Indigenous elders participating in this study, would go with us to the sea (in an out-of-school context) and explain to the science teachers the traditional beliefs and hopefully demonstrate some of the cultural practices they usually perform at the sea. Unfortunately, he explained to us that he was not allowed (by the ancestors) to go to the sea except when he went to perform rituals or traditional ceremonies and cautioned that if we went something bad could happen. To minimise risks and out of respect for him we had to adjust our approach and allow him to explain everything we needed to know without going to the sea to accommodate cultural complexity (Chilisa, 2012; Mertens, 2010).

In this study, it was hoped that through document analysis and workshop discussions, the participating science teachers and I could co-develop exemplar lessons that integrated local IK to bring about transformation in the teaching of these and other science topics that the teachers chose. Furthermore, drawing from the epigraph stated above, the use of the isiXhosa language (since the participants are isiXhosa speakers) as an emancipatory tool was envisaged to increase access to knowledge of Physical Sciences in general, and specifically of the topics on waves and sound and redox reactions concepts.

My interest was in the intersection of how the two paradigms complemented each other during knowledge construction and the entire research process. As alluded to earlier, Seehawer and Breidlid (2021) proffer that in the intersecting space (third space) there is a dialogue between IK and WS. Within these paradigms, a case study research design was employed as explained below.

4.3 Research Design

According to Bertram and Christiansen (2019), a research design is a plan or strategy of how the researcher will systematically gather and analyse the data that is required to answer the research question to fulfil the purpose of the study. In other words, a research design is a tool used to attempt to answer the research questions.

This was a qualitative case study which used a Participatory action research (PAR) approach. My main goal was to leverage the use of a Lesson Study approach when working with science teachers on how to integrate IK to mediate learning of the topics of waves and sound and redox reactions in a township school. To Creswell (2008), a case study is a comprehensive investigation of a confined system. Similarly, McMillan and Schumacher (2014) define a case study as a systematic and in-depth study of a particular case in its context or single entity. Likewise, Cohen et al. (2018) view a case as an enquiry which focuses on a single phenomenon, which is studied in its real-life context with the intention of understanding the peculiar dynamics related to the case.

My case in this study consisted of six purposefully selected science teachers from a township combined school (from grade R to grade 12) and four IKCs. These teachers were involved in document analysis and participated in various workshops to improve their PCK. In addition, a language teacher from the same school (teaching isiXhosa and English) as my critical friend and two university lecturers ran workshops for us on document analysis and Lesson Studies, respectively, and a school principal from Zambia presented on the African perspective of the Lesson Studies. Also, five IKCs (all Xhosas) from the same township shared their IK with our PLC. Umhlekazi, Majeke and MaMtshawe talked about cultural beliefs and practices related to the sea, waves and sound, MaMcirha shared the IK on homemade bread and Mnqarhwane shared his cultural heritage on traditional music. In addition, a critical friend, Nozinga, who is also a university lecturer facilitated a workshop for our PLC on hands-on practical activities using easily accessible resources.

Thus, the qualitative case study adopted a participatory approach (Ngcoza, 2007; Seehawer, 2018) underpinned by the Ubuntu[4] perspective as alluded to earlier. My unit of analysis was the integration of IK into science teaching and how the teachers' PCK shifted during the process. I chose a case study because I believed that it would provide me with in-depth information on how to mediate learning when IK is integrated into the teaching of waves and sound and redox reactions (Cohen et al., 2018). In addition, a case study uses different data-gathering instruments to capture data from different angles which helped in validating data as

[4] Ubuntu is an African-centred worldview that emphasises the good-of-all, harmony, mutual respect, relational understanding, interdependence, interrelationships, or interconnectedness of all phenomena (Ogunniyi, 2018; Seehawer, 2023).

it was intended in this study. Within the case study, I used the Lesson Study and the PAR approaches.

4.3.1 Lesson study approach

According to Ono and Ferreira (2010), the expression 'Lesson Study' finds its origin in the Japanese word *jugyokenky* (*jugyo* means a lesson and *kenky* means to study or research) and was originally a peer observation-based model. Cordingley et al. (2004) explain that Lesson Study has been introduced in various countries as a form of teacher professional development that involves a cyclic process of *lesson planning*, *collaboration*, and *reflection*. They further argue that for any teacher development to be effective, it should be ongoing and must provide opportunities for teachers to experience and reflect on activities. Lending support, Lenski et al. (2009, p. 50) stated that "the Lesson Study approach is a method of professional development that encourages teachers to reflect on their teaching practice through a cyclical process of collaborative lesson planning, lesson observation and examination of student learning".

Similarly, Alshwaikh and Adler (2017) explain that Lesson Studies is a form of teacher development that is collaborative and cyclical and aimed at improving teaching through reflections. This resonated with the main goal of this study which was to leverage the use of a Lesson Studies approach when working *with* science teachers on how to integrate IK to mediate learning of the topics of waves and sound and redox reactions in a township school.

Perry and Lewis (2009) clarify that a Lesson Study is a cycle of instructional improvement in which teachers work together to formulate goals for student learning and long-term development. They further explain that teachers sit together and plan a 'research lesson' designed to ensure that the planned goals are realised; then one of the teachers from the PLC enacts the lesson in a classroom while other members observe and take notes. Also, the lesson was videotaped to be used during stimulated recall discussions later. Thereafter, our PLC reflected on the lesson and discussed areas of improvement, then repeated the cycle if they saw a need to do so. This suggests that participatory action research (PAR)is embedded in Lesson Studies albeit not made explicit.

As alluded to earlier in the problem statement, professional development workshops (run by the Department of Education) that I have attended usually take a few hours and little or no time is allocated for discussion and reflection. During those workshops, teachers are expected to take notes and are expected to go back to their respective schools and implement what they had

been workshopped or trained on. In contrast, Ngcoza and Southwood (2019) emphasised the importance of a participatory and emancipatory approach (like Lesson Studies) to teacher professional development that is based on mutual and collaborative support.

In this study, six science teachers and I collaborated as a CoP (Lave & Wenger, 1991; Wenger, 1998). In terms of the Lesson Study approach, our activities were informed by principles of Ubuntu whereby secondary school teachers learned from Foundation and Intermediate Phases teachers, and that talks to mutual benefit. We co-analysed documents related to specifically chosen topics, co-designed exemplar lessons, and implemented and reflected on the learning strategy (Lewis, 2002). This approach resonates well with Fullan's (2011b) view that effective professional development should involve active collaborative learning experiences that provide teachers with the opportunity to adopt practices for their classrooms. The co-developed lessons were owned by the PLC rather than being individualistic and resulted in transformative learning. It was hoped that this Africanised Lesson Study approach would help improve the teachers' knowledge of the integration of IK into learning and the quality of learning resources (Lewis et al., 2009) as they engage in PAR.

4.3.2 Participatory action research approach

Participatory action research (PAR) is a form of action research in which professional social researchers (like teachers) operate as full collaborators with members of organisations (such as a school and expert community members) in studying and transforming these organisations (Greenwood et al., 1993). According to Robinson (2002), PAR is based on the principle that the knowledge gained through the research process is owned by the participants so that they reflect on and improve their practice in an ongoing manner. Thus, central to PAR is to address the participants' social, educational, and material needs (Ngcoza, 2007). Agreeing, Kemmis (2012, p. 56) refers to PAR as a "practice-changing practice" and indeed this is central in this study.

The PAR approach seemed appropriate in this study since one of its objectives was teacher development using a Lesson Studies approach in mediating learning. In addition, it is my view that a PAR approach might create an enabling and empowering environment for all the participants as espoused by the transformative paradigm. This resonates well with Kemmis et al. (2014) who highlighted two features of PAR:

- the recognition of the capacity of people living and working in particular settings to participate actively in all aspects of the research process; and
- the research conducted by participants oriented to making improvements in practices and their settings by participants themselves.

Participatory action research (PAR) involves continuous self-reflective cycles (Kemmis & Wilkinson, 1998, p. 21), namely:

- assessing and reflecting on practice;
- planning change;
- acting and observing the process and consequences of the change;
- reflecting on these processes and consequences; and then
- re-planning, and so the spiral continues.

To Kemmis and Wilkinson (1998), the self-reflective process is not linear but iterative. They further emphasise that success is not measured by following these steps rigidly. Instead, it is measured by the actors' (science teachers, in this case) demonstration of understanding their practice and the context in which they practice it (in the context of my study this refers to a township school). I am mindful of the fact that a Lesson Study approach lends itself to being participatory in nature but in the context of this PAR it has been emphasised as it resonates with both the Indigenous research and transformative paradigms.

4.4 Research Goal and Research Questions

The main goal of this study was to leverage the use of a Lesson Study approach when working *with* science teachers on integrating Indigenous Knowledge to mediate learning of waves and sound and redox reactions in a township school. This goal was achieved by answering the following research questions:

1. What are the science teachers' perspectives, pedagogical insights, and practices regarding integrating Indigenous Knowledge in science teaching?
   (a) What are science teachers' perspectives and pedagogical insights regarding integrating Indigenous Knowledge into their teaching before the intervention?
   (b) What are science teachers' classroom teaching practices before the intervention?

2. What learning opportunities are created for the science teachers through capacity-building workshops by critical friends before the intervention?
3. What learning opportunities are created (or not) during the presentations by the Indigenous Knowledge Custodians?
4. What learning opportunities are created (or not) during hands-on practical activities on 'kitchen chemistry'?
5. How do science teachers co-develop and then enact their exemplar lessons that integrate Indigenous Knowledge into the topics of waves and sound and redox reactions?

4.5 Research Site and Selection of Participants

The study was conducted in a township school in a coastal town in Sarah Baartman District in the Eastern Cape, South Africa. The school is in quintile 3 and categorised as a no-fee-paying school, which means it depends on government funding and donations from the community members to be able to perform its function. This school is one of the top-performing schools in the district (in the top five in terms of matric results). For instance, in 2020, the school produced the top two learners in the previously disadvantaged category (these learners were also the top science and maths achievers and both are currently studying for BSc degrees at Rhodes University and are doing extremely well) and the school is in partnership with Rhodes University (the school also accommodates the Bachelor of Education (BEd) and the Postgraduate Certificate in Education (PGCE) students from Rhodes University to do their teaching practice).

In 2022, the school produced a 100% matric pass rate and once again produced the top two achievers in the district (this time around from the commerce department). Indeed, this school is a beacon of hope for the Port Alfred Black community and is currently seeking strategies to sustain and improve its academic excellence, especially in science and mathematics. Below are pictures of the school (Figure 4.1) and the Sarah Baartman District as a whole (Figure 4.2).

Figure 4.1: The township school where the research was conducted

Figure 4.2: Map of Sarah Baartman District (https://www.ecdoe)

According to Bertram and Christiansen (2019) sampling includes making decisions about which people and how many to choose events and roles or behaviours to include in a study. In this study I worked with science teachers from one township school. Six purposefully sampled science teachers from a combined township school (from grade R-12) and I, a Physical Sciences teacher and a headmaster at this school participated in this study.

Purposive sampling was preferred because the ultimate goal of my study was to capacitate the science teachers to integrate IK into their science lessons. All six science teachers were

qualified teachers with different teaching experiences and taught different grades and subjects. For example:

- One teacher taught Physical Sciences grade 12, mathematics grade 11 and Computer Applications Technology grades 11 and 12 (in the FET Phase).
- The second teacher taught Natural Sciences grade 4 and English and Life Skills, grade 7.
- The third teacher taught Natural Sciences in grades 6 and 7 in the Intermediate phase.
- The fourth teacher taught Life Sciences grades 10, 11 and 12 (FET Phase) and Natural Sciences grade 8.
- The fifth teacher taught Physical Sciences grade 10 and mathematics grades 9 and 10.
- The sixth teacher taught Life Skills in grade 2 and mathematics in the Foundation Phase.
- I teach Physical Sciences grade 12 and mathematics grade 12, as detailed in Table 4.1 below.

In addition, one language teacher (isiXhosa and English), three university lecturers and a school principal from Zambia participated in this study as my critical friends. The language teacher assisted with language issues and facilitated the reflection workshops during the research process, and the university lecturers helped facilitate various workshops, such as document analysis and the Lesson Study approach. In addition, five community members (IKCs) also participated as *omakadebebona bezakwantu* (experts on IK), who were regarded as MKOs (Vygotsky, 1978) based on their expertise in IK. I chose the school because it is where I conducted my master's research where the focus was on working with learners. However, this time around I worked with the teachers. Notably, two of the teachers were my critical friends in my master's research project.

Secondly, I chose the school because I knew that the school was a high-performing school and at the time of the study was looking for ways to sustain its academic excellence. Thus, this study might catalyse whole school development, as the six teachers and I were involved in document analysis on the topic of waves and sound and redox reactions and at the same time were engaged with five expert community members who were knowledgeable about IK. In this study, I have used *omakadebebona* and the expert community members interchangeably. It was hoped that the six teachers would have the opportunity to share their experiences with the whole school and contribute to teacher development for meaningful Continuing Professional Teacher

Development, and hopefully, that might impact positively on the pedagogical practice of the teachers.

Table 4.1: Participants' profiles

Pseudonym	Age	Gender	Academic/Professional qualifications	Country & place of birth	Teaching experience
MaNgconde	37	Female	BEd (science and mathematics methods)	South Africa (Bathurst)	10
Madiba	43	Male	BSc (physics & mathematics majors); HDE	Cameroon	14
MaMyeka	55	Female	Senior Primary Diploma, ACE, BEd, currently completing BEd Honours	South Africa (Makhanda)	27
MaMhegeba	57	Female	Senior Primary Diploma, BEd Honours	South African (Gqeberha)	29
Zizi	59	Male	Secondary Teacher's Diploma	South African (Peddie)	32
MaMpehle	28	Female	Foundation Phase Teachers Diploma	South Africa (Port Alfred)	2
MaMsukwini (critical friend)	29	Female	BA degree (English and Sociology) and PGCE Foundation Phase	South Africa (Makhanda)	3

Table 4.2: IKCs who participated in the study

Pseudonym	Age	Gender	Academic/Professional Qualifications	Country & Place of Birth	Experience/Occupation
Majeke	68	Male	Standard 6	South Africa (Port Alfred)	Retired groundsman and a Lay preacher
MaMtshawe	58	Female	Grade 12 and Diploma in Financial Management	South Africa (Port Alfred)	14 years as a school clerk

MaMcirha	52	Female	Standard 6	South Africa (Peddie)	Admin cleaner for 5 years/ worked as a domestic worker before
Umhlekazi	55	Male	Standard 8	South Africa (Mbizana, Transkei)	Been practising as a Sangoma for more than 30 years
Mnqarwane	60	Male	Standard 5	South Africa (Port Alfred)	General worker for 3 years and worked for an electricity company before

4.6 Data-Gathering Methods: The Research Process

The aim of this study was to leverage the use of the Lesson Study approach when working *with* science teachers on how to integrate IK to mediate learning of the topics on waves and sound and redox reactions in a township school. To achieve this, I sought counsel from Chikamori et al. (2019) who offered a three-phased model of learning as shown in Figure 4.3 below.

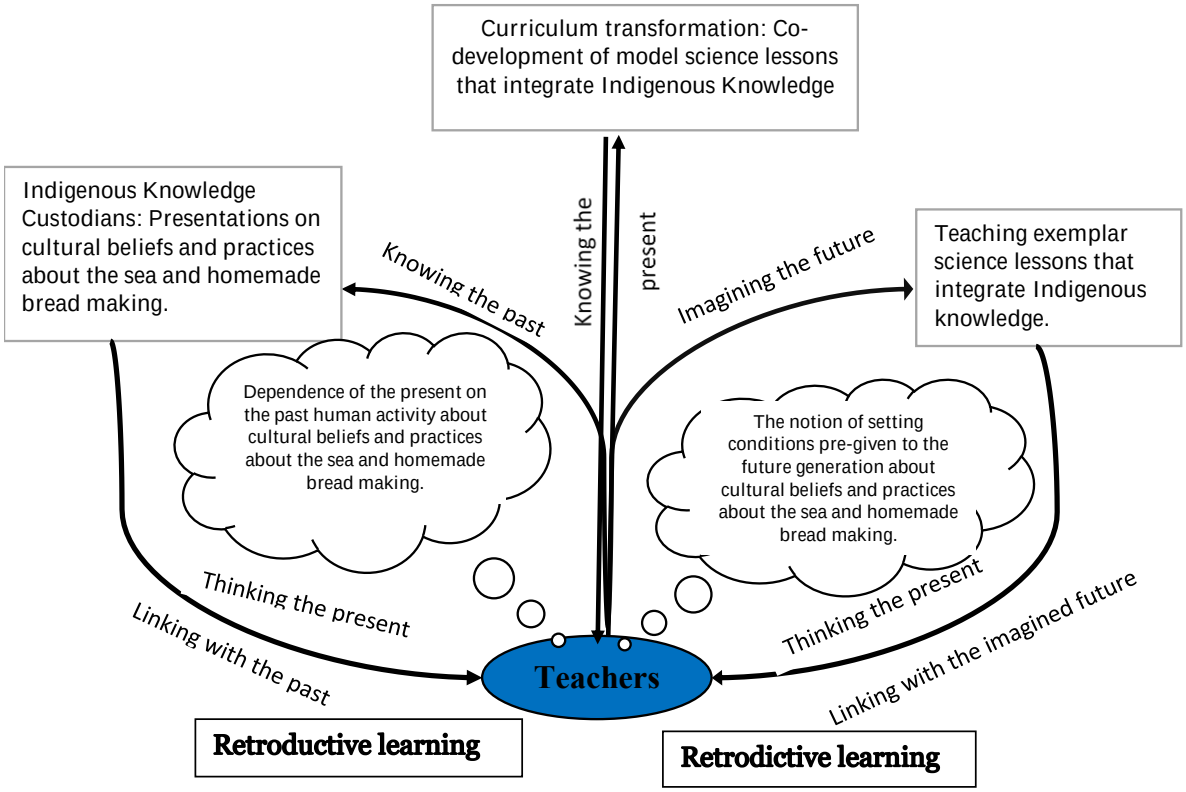


Figure 4.3: The three-phase model of learning. Adapted from TMESD of Figure 2 in Chikamori et al. (2019, p. 9)

In this diagram, Chikamori et al. (2019) illustrate the three interrelated learning phases in this study, namely knowing the past, knowing the present, and imagining the future. It involved what Chikamori et al. (2019) called *retroductive* and *retrodictive* learning. Retroductive learning refers to 'past-present' relationships, in other words how current events are influenced by both the past and the present. On the other hand, retrodictive learning refers to future-present relationships. In his study conducted in South Africa, Mutanho (2021) adapted this model to illustrate the process involved in the integration of IK to support in-service teachers to co-develop and enact exemplar science lessons. Similarly, I adapted this model in my study.

In the case of my study, science teachers were exposed to several IKCs. For instance, a Sangoma (a traditional healer) came to our school to share his knowledge on IK related to the sea, traditional rituals and how to handle learners at school who claim that they are called to be Sangomas. Secondly, we went to the sea (out-of-school context) with other IKCs who shared the history of that sea and cultural beliefs and practices related to waves and sound. Lastly, another IKC came to the school and shared with the teachers how to make homemade bread using traditional methods. This could be viewed as new knowledge.

The research process consisted of six phases (refer to Appendix D for further details). Below I briefly outline the research process that was followed in this study.

The research process consisted of six phases (see Appendix D). The first phase sought to answer research question (RQ) 1. In this phase, focus group discussions in the form of sharing circles were used to gather the baseline data before any intervention took place. This was followed by phase 2 which sought to answer RQ 2 and aspects of RQ 3. This phase consisted of four pre-intervention workshops, namely, an orientation workshop whose aim was to familiarise the participants with the study, followed by a workshop on reflections to capacitate the teachers on journal reflections. The third workshop was on Lesson Studies to expose the teachers to the approach employed in this study. Phase 2 concluded with a workshop on document analysis and the TSPCK analytical tool to help teachers unpack and analyse curriculum documents (focusing on the two topics of waves and sound and redox reactions).

To gather rich data to answer aspects of RQ 3, phase 3 was deemed necessary in this study. In this phase, participatory observations and journal reflections were employed to explore whether learning opportunities were created (or not) during the presentations by IKCs and critical friends. To answer RQ 4, phase 4 followed which was a reflective space wherein our PLC

reflected on the demonstration and explanation received from the community members and the document analysis. This was followed by a workshop on the co-developed exemplar lessons on waves and sound and redox reactions. To answer RQ 5, two science teachers presented our two co-developed lessons, one on waves and sound and the other on redox reactions respectively. Lesson observations were conducted using the TSPCK components for the transformation of knowledge and stimulated recall interviews and journal reflections were used as data-gathering tools in this phase. This was done to give a voice to the participants and for validation of data. Lastly, phase 6 was a workshop on the kitchen hands-on practical activity (on redox reactions). The aim of this workshop was to assist the science teachers in mediating the teaching and learning of redox reactions. Data was gathered through participatory observation and journal reflections which helped to answer RQ 4. The different phases of the data-gathering process of this study are outlined in Table 4.3 below.

Table 4.3: The tools, methods and purpose for the gathering of information

Phase	**Method to be used to gather data**	**Purpose**	**Research questions**
Phase 1	Focus group discussions – sharing circles	To solicit teachers' views and perspectives on the integration of IK into science lessons. Thereafter, I observed two teachers using the traditional method of teaching the lessons on waves and sound and redox reactions to gather my mirror data. This was followed by four different workshops.	1
Phase 2	Pre-intervention Workshops Discussions & Reflections	Orientation workshop to orientate the participants about the study. -Workshop on reflections to capacitate the teachers on journal reflections. -Workshop on Lesson Studies to expose the teachers to this approach employed in this study. -Workshop on document analysis and the TSPCK analytical tool to help teachers unpack and analyse curriculum documents (focusing on the two topics on waves and sound and redox reactions). This was followed by two workshops.	2 & 3
Phase 3	Participatory observations and journal reflections	To explore if learning opportunities are created (or not) during the presentations by IKCs and critical friends.	3

Phase 4	Group reflections (Workshop discussions and journal reflections)	The PLC will reflect on the demonstration and explanation received from the community members and the document analysis. Co-develop exemplar lessons on waves and sound and redox reactions.	4
Phase 5	Lesson observations (videotaped lessons), stimulated recall interviews and journal reflections	At least two science teachers will present the lesson. TSPCK components for the transformation of knowledge will be used. To give *voice* to the participants and for validation of data.	5
Phase 6	Participatory observation and journal reflections – kitchen hands-on practical activity	Kitchen hands-on practical activity (on redox reactions). To assist teachers to mediate teaching and learning of the redox reactions.	4

Now I present the data-gathering methods of the study in detail.

4.6.1 Focus group discussions - sharing circles

Initially, I had planned to use semi-structured interviews to generate baseline data to answer research question 1 (RQ1) which sought to understand the science teachers' perspectives and pedagogical insights on the integration of IK into their teaching. Semi-structured interviews are a conversation between the researcher and the participants (Cohen et al., 2018). Maree (2014) views an interview as a two-way process, in which the interviewer asks participants pre-determined questions to collect data and gain insights into the participants' views and attitudes about a subject.

However, I realised as I engaged with our PLC during the orientation workshop that some of the participants seemed uncomfortable with the idea of interviews, especially with science-related questions. Guided by Chilisa (2012) and consistent with the Ubuntu approach (see Section 4.2.2), I explored the alternative method of sharing circle group discussions that incorporated *storytelling* and cultural nuances (Tachine et al., 2016). Kovash (2010) views sharing circles as an open-structured, conversational style methodology that respects story sharing within a tribal cultural protocol context. Indeed, during our focus group discussions,

we followed the cultural protocol when the science teachers were interviewed to get in-depth data on the science teachers' experiences and pedagogical insights regarding the integration of IK into their science teaching.

For that reason, in this study, I chose to use focus group discussions which were in the form of a sharing circle (Chilisa, 2012; Lavallee, 2009; Struthers et al., 2003). Furthermore, Rothe et al. (2009) pointed out in that sharing circles provide a suitable platform for levelling the power dynamics or gradients and discussing issues and topics in an egalitarian, supportive, and non-confrontational manner. Indeed, it was critical for me to use a strategy that was non-threatening and friendly. In addition, sharing circles cannot be conducted with Indigenous people without following traditional protocols (Carr et al., 2020; Chilisa, 2012), which in this study were key since I worked with Indigenous people and employed Ubuntu perspectives (Seehawer, 2023). Chilisa (2012) and Struthers et al. (2003) refer to sharing circles as talking circles.

I used sharing circle discussions to interview the six science teachers who participated in the study. I took notes while my critical friend videotaped the session. The sharing circle discussions took about two hours and were videotaped with the permission of the participants. Supporting videotaping, Merriam (2009) contends that it allows the capturing of not only verbal but also non-verbal communication such as movements and facial expressions. Resultantly, I analysed the videos and used them during the stimulated recall discussions to get more information and clarity. In this study, I have used the terms 'sharing circles' and 'focus group discussion' interchangeably. A sharing circle is an open-structured, conversational style methodology (as shown in Figure 4.4 below) that respects *story* sharing within a tribal cultural protocol context (Kovach, 2010).

Figure 4.4: Showing our sharing circle

In line with the Indigenous approach, I chose to use focus group discussions where we sat in a sharing circle as the Indigenous people used to do in the olden days where I grew up (Chilisa, 2012; Lavalle, 2009), because they allowed us to engage freely with each teacher, and also get an opportunity to ask follow-up questions to obtain in-depth information required to be able to answer my research questions (Cohen et al., 2018; Thomas, 2013). In addition, sharing circles are also useful in levelling power gradients (Chilisa, 2012). During the discussions, people took turns to answer a particular question and were given the opportunity to add to what other speakers had said and perhaps elaborate further. I adapted the interview schedule from Cetin-Dindar and Geban (2017) to elicit the science teachers' perspectives about the integration of IK into science teaching since it is a tested tool that seemed relevant to my study (see Appendix E).

The sharing circle discussions were conducted in the afternoon at the school in one of the classrooms. We agreed to use afternoons so that the study would not interfere with teaching and learning. The afternoon classes were special classes arranged for the purposes of this study. As indicated in the consent letter to the learners. In other words, we could refer to these as artificial lessons. The reason for using afternoon classes was that we did not want to disadvantage those who opted not to take part in the study. However, if there were learners who decided not to take part I would have designed activities for those learners. The discussions took between three and four hours and I asked the questions in English and explained them in isiXhosa. I explained that there were no right and wrong answers and I encouraged the teachers

to use the language of their choice. Interestingly, the teachers took turns answering the questions and I guided the process.

The sharing circle discussions were videotaped with the permission of the participants and later transcribed, and we also used the videos during the stimulated recall discussions. I also wrote down some notes and comments from the teachers for later use. After the discussions, the teachers commented that they enjoyed the sessions, and that indicated to me that the environment was friendly.

4.6.2 Pre-intervention workshops

In this study, the science teachers were exposed to a series of workshops to support them in mediating the teaching and learning of science by integrating IK. A Lesson Study approach was employed in this study as a tool to help bring about the desired change. In this study, workshop discussions were deemed relevant as they set an environment for social interaction and collaborative learning for our PLC (Vygotsky, 1978). Also, Eun (2008) views workshops as the best platform to improve teaching and learning through engaging teachers in professional development activities. Below I briefly discuss each of the workshops conducted in this study.

4.6.2.1 Orientation workshop

A particular goal of this workshop was to orientate the participants about the study. Firstly, I introduced myself as a researcher and the participants also introduced themselves so that we all got to know each other. I explained to the participants that the aim of the study was to assist the science teachers to get a better understanding of the IK related to the topic on waves and sound and redox reactions. Given the nature of the study and to level power dynamics we agreed to use clan names to address each other. In the African culture, clan names are used to level power gradients (Mutanho, 2021). Furthermore, the role of each participant and the research process were clearly outlined, and room was provided for questions and comments.

It was during this workshop where we agreed that we should meet after school or prepare activities for our learners and request the education assistants to supervise the lessons so that teaching and learning was not compromised. I explained to the participants the importance of evidence-based data for the validity and trustworthiness of the study and requested to videotape our meetings and take pictures. Permission to videotape and take photos for the purposes of the

study was granted by the participants. As alluded to earlier I analysed the videos and transcribed, and we also watched the videos during our stimulated recall discussions.

4.6.2.2 Workshop on reflections

During the orientation workshop, the importance of reflecting throughout the study was emphasised. After explaining that the reflective journals were personal artefacts, the participants were requested to each have a special reflective journal for the purposes of this study and told that they were going to be used as part of the data collection. We agreed that after each presentation or interaction we were going to have a reflective space wherein each person would be given a chance to read their reflections. During our first reflective meeting, I observed that the teachers seemed to find writing reflections challenging. Thus, a gap was identified, and I saw this as an opportunity to capacitate the science teachers on how to reflect and experience the power of the reflective journal.

To do this, I used the learner videos as a resource. We all watched the videos of my former grade 10 learners. Thereafter, the science teachers asked questions such as: *Did you give the learners the sub-headings for reflection*? Or *are we allowed to write in isiXhosa and reflect in English or both*? To such questions, answers were provided to the satisfaction of the participants.

4.6.2.3 Workshops on lesson studies

Two virtual workshops on the Lesson Study approach were held on separate days. The first workshop was conducted by a university lecturer from Japan who presented on the origins of Lesson Studies. Noteworthy, is that he indicated that in Japan, the education department officials approach retired academics and retired teachers who have worked in or with the education sector over many years and have much experience on educational issues and teaching approaches. These people formed a professional learning community (PLC).

He posited that these people had more time to plan, and their involvement did not have any financial impact on the state. The experts with the teachers from various districts thus come together and share their expertise in the form of discussion workshops. Together, they co-develop exemplar lessons, and then the teachers go back to their various schools and enact those lessons – the experts serve as critical friends. Afterwards, they come together and reflect on the lessons and identify areas of improvement, and then the circle continues. He emphasised the planning, consultation and commitment from all parties involved. He also indicated that he

had been monitoring the South African curriculum and its education system and he felt that this country still had a long way to go.

In addition, a second virtual workshop on Lesson Studies was organised. The focus of the second workshop was the African perspective on the implementation of the Lesson Study approach in Africa. A school principal from Zambia presented to our PLC. In his presentation, he highlighted the mobilisation of parents and other stakeholders. For instance, according to him, parents were invited to schools to share their skills with learners, such as art, painting and weaving and drum making. He indicated that there was a political will from their government. The teachers engaged with him asking questions related to time management and the curriculum, which he explained in detail.

4.6.2.4 Workshop on document analysis

A face-to-face workshop on document analysis was facilitated by a university lecturer who was a critical friend in this study. The workshop was videotaped with the permission of the participants; it started at 8 am and ended at 4 pm with all participants in attendance. As indicated earlier the videos were analysed and transcribed and were later used for stimulated recall discussions. The facilitator introduced himself as Ndlovu, his clan name, and asked everyone to introduce themselves – we all used our clan names to introduce ourselves. Ndlovu indicated that he was aware of the goal of the workshop, which was to help our PLC unpack the curriculum on waves and sound and redox reactions. However, he suggested that we briefly look at Piaget's theory of learning and Vygotsky's SCT; this was done to enlighten the participants about the theories used in this study and their relevance. Secondly, Ndlovu went on to explain Mavunga and Rollnick's (2013) TSPCK and how the components of TSPCK were going to be used to unpack the curriculum. We focused on the two topics of interest in this study using the CAPS document, ATP, Examination grades 10–12 Physical Sciences textbooks (a different textbook for each grade), Examiners Reports from 2017 to 2021 and examination papers for five consecutive years (2016–2020).

After lunch, Ndlovu asked the PLC to split into two groups; group one focused on the topic on waves and sound and group 2 focused on redox reactions. Mavhunga and Rollnick's (2013) TSPCK tool helped the science teachers unpack the aforementioned documents and scrutinise them from different angles. The five components of TSPCK helped us identify the discrepancies and alignments between CAPS and the ATP, the textbooks and the examination guidelines.

During the analysis, the interactions were characterised by teacher talk, asking questions, providing answers and pointing out their findings. It was interesting to see such collaboration and sharing of ideas. Initially, we planned to work up until 3pm but the teachers indicated that we should carry on until 4pm.

4.6.2.5 Workshop on co-development of exemplar lessons

I facilitated the workshop on the co-development of exemplar lessons. We adopted the following approach for the co-development of our exemplar lessons:

- We split into two groups of three (same groups as before); one group to focus on waves and sound and the second group to focus on redox reactions. Each phase was to be represented in a group, for example, by one teacher from the Foundation Phase /Intermediate phase, one teacher from the Senior Phase/Intermediate Phase and one teacher from the FET Phase.
- The co-development of the exemplar lessons was to be guided by the findings of the document analysis.
- Lessons learned from the presentation on Lesson Studies were be used during the co-development of the exemplar lessons.
- We needed to explore the possibility of the integration of relevant IK from the presentations by the IKCs.
- We should include suitable examples of IK from our communities.
- Thereafter, each group had to present the refined exemplar lessons.
- The two teachers who taught the pre-intervention lessons were asked to teach again, so that we could observe the shift in terms of IK.

The equal use of isiXhosa and English (translanguaging) seemed to propel the discussions forward (Mapfumo, 2024). I moved between the two groups in my capacity as a participant observer.

4.6.3 Document analysis

Wong et al. (1982) explain document analysis as a system that could be applied to extract information from printed documents to create a database. Agreeing, Bowen (2009) views document analysis as a systematic procedure for reviewing or evaluating documents, both printed and electronic materials. Corbin and Strauss (2008) accentuate that like other analytical

methods in qualitative research, document analysis requires that data be examined and interpreted to elicit meaning, gain understanding and develop empirical knowledge. It was acknowledged that I needed to invite someone more knowledgeable about document analysis to conduct a workshop for us before we could do the actual document analysis.

Indeed, a university lecturer facilitated the workshop on document analysis, and he acted as a critical friend (he also took time to motivate the science teachers to work as a team and support each other). In this study, the six science teachers and I constituted a PLC, and with the aid of Mavhunga and Rollnick's (2013) five TSPCK components (see Appendix G) we analysed the following documents: curriculum documents (CAPS), the Annual Teaching Plans (ATP), the DBE examiners' reports and science textbooks (Grades 10-12) to gain some insight which informed the co-development of exemplar lesson plans. This workshop prepared us for the next work of the co-development of exemplar lessons.

4.6.4 Observations

The purpose of observations is to get first-hand information on the phenomenon. Observations provide a direct and powerful way of learning about people's behaviours and the context in which this occurs (Maxwell, 2012). In this study, three phases of observations were employed, namely pre-intervention lesson observations, participatory intervention observations and post-intervention lesson observations. I decided to use this approach because I thought it would provide me with a window to see if there was any shift or not in the teachers' ZPD and PCK in terms of IK integration after the post-intervention lesson observations. In my view, it was crucial to observe how the study had influenced the teachers' perceptions on the integration of IK. During the presentations I observed and took notes while my critical friend videotaped the presentations. Thereafter, I analysed the videos and transcribed them. Also, as a participatory observer I asked some probing questions and during document analysis, I assisted the teachers on how to use the TSPCK as an analytical tool.

4.6.4.1 Pre-intervention observations

There were two pre-intervention lesson observations. The first one was on waves and sound, and it was taught by MaNgconde. The lesson took 55 minutes, and it was videotaped by my critical friend (MaMsukwini) so that I could focus on the observations. During the lesson I took notes. The second lesson on redox reactions was taught by Madiba; it also took 55 minutes and

was videotaped by MaMyeka. Similarly to the first lesson, I focused on observation and took some notes.

4.6.4.2 Participatory observation

Participatory observation is a systematic process of recording the behavioural patterns of participants, objects and occurrences without necessarily questioning what they do or communicating with the participants (Creswell et al., 2016). In this study, I positioned myself as a co-learner, so during the research process, I posed questions for further clarification and to elicit more knowledge about IK from the IKCs. I also guided the teachers to explain the science behind each presentation by the IKCs. For instance, during the hands-on practical activities by Nozinga, I helped MaMpehle at the start of the activities until she was confident enough to work on her own. Also, during document analysis, I assisted with how to use the TSPCK as an analytical tool.

Participatory observation is consistent with indigenous research methodologies, and as alluded to earlier, I positioned myself as a co-learner in this study. In my study, participatory observations were in the form of presentations by the IKCs. Firstly, Mhlekazi was a Sangoma (a traditional healer) and had been practising for more than 30 years and was knowledgeable about traditional beliefs and practices related to the sea; he was also knowledgeable about ancestors and spirituality. Mbiti (1977, p. 76) reminds us that "the African view of the universe or the world, understand spiritual mediators (ancestors) as people who fill up the area between man and God". Illuminating this view further, Masango (2006) in his study of *African spirituality that shapes the concept of Ubuntu* concluded that "elders within the village become leaders, and towards the end of their life journey, they become teachers and good ancestors, especially to younger generations". Masango emphasised that they would become good ancestors if they lived a good life. Thus, in the context of this study, Mhlekazi was regarded as an MKO (Vygotsky, 1978).

Secondly, Majeke's and MaMtshawe's collaborative presentation (oral) was about the cultural practices at the sea, which was in an out-of-school context (Alshwaikh & Adler, 2017). They presented to our PLC in isiXhosa, and their presentation took about an hour and was videotaped. Initially, Majeke was going to present alone but on the day of the trip, MaMtshawe, (who is a school clerk) requested to join us. Guided by the principles of Ubuntu we could not say no and when Majeke was presenting she co-presented with him without anyone asking her to do so. Her contribution was well received by everyone as she proved to be clear about

cultural issues related to the sea and about the history of events related to the sea in Port Alfred. Majeke explained more about high and low tides from an IK perspective and explained how they were related to the full moon, half-moon and quarter moon. We learned so much from the presentations of these IKCs.

Thirdly, MaMcirha demonstrated how the homemade bread was made from the beginning; that is from making the dough, covering the dough and waiting for it to rise, and finally cooking and serving the bread. She presented with confidence in isiXhosa, asking some probing questions (elicitation of prior everyday knowledge as espoused by Kuhlane) (2011), predicting and answering questions. She explained the 'what', the 'why' and the 'how' of the entire process which was contrary to Taylor and Cameron's (2016) view that IK and WS seem to intersect at the *know-how* and *know-what* but not at the *know-why*. Her presentation was very informative and was well received by our PLC especially by the women (Amutenya, 2023), who confessed that they had learned a skill from MaMcirha.

Lastly, Nozinga from the chemistry department at Rhodes kindly facilitated a workshop on the use of easily accessible resources to promote hands-on practical activities (Asheela et al., 2021). The workshop took about three hours and was videotaped, and pictures were taken.

4.6.4.3 Lesson observations (post-2 classroom observations)

Cohen et al. (2018) posit that observation is about a researcher going to the research site to collect first-hand information from participants. In this research and consistent with the Lesson Study approach, we conducted observations of two lessons by the participating teachers. After we had developed exemplar lessons that integrated IK, two science teachers volunteered to present them on separate days while we observed how they presented them. I believed that lesson observations were crucial in this study because they served as a window to see the effect of the workshops on IK integration and the importance of hands-on practical activities. During lesson observations, we wrote some field notes and two other teachers video-recorded the lessons with the consent of all the participants (see Appendices B4, B5, and B6). After the lesson observations, we arranged to watch the videos as the PLC and engaged in stimulated recall discussions (Chilisa, 2012; Maxwell, 2012).

The first lesson was taught by Madiba in English, and it was on redox reactions. The lesson took an hour, and it was presented to 14 grade 11 Physical Sciences learners and four grade 12 Physical Sciences learners. The grade 12s were invited for revision purposes as the focus was

on grade 11 work. Madiba introduced the lesson by outlining its objectives using a PowerPoint presentation. He employed a *storytelling* approach to narrate how Indigenous people from his home village used to extract iron and how they managed to make agricultural tools and weapons from the process. This approach kept the learners captivated as they listened attentively. Then Madiba used a practical demonstration of an apple exposed to air and solicited the learners' prior everyday knowledge to explain their observations (Kuhlane, 2011). He then used the learners' responses to enable 'border crossing' (Aikenhead & Jegede, 1999) to explain the process of oxygen transfer before going on to the electron transfer and chemical equations. I observed that the learners were engaged throughout the lesson, and they seemed to be enjoying the lesson.

The second lesson was presented to the grade 10 class by MaNgconde on waves and sound. She used my master's video on the presentation by Majeke to the then grade 10 learners who were now in grade 12. After watching part of the video for about 10 minutes, she asked questions about cultural beliefs and practices that they knew, thus soliciting their everyday prior knowledge. After a moment of silence, she told the learners that they were allowed to speak in isiXhosa. Afterwards, MaNgconde turned her focus to science concepts and how they were related. For instance, she introduced the concept of a pulse and moved from a pulse to a wave and the wavelength, showing the links. Notably, the learners seemed to follow as she was logically explaining how the concepts were related. It seemed that the learners were enjoying the lesson and effective learning was taking place (Asheela et al., 2021; Mahakure & Otulaja, 2017; Vygotsky, 1978). She concluded the lesson and gave the learners a worksheet to do at home.

4.6.5 Stimulated recall discussions

In this study, I conducted stimulated recall discussions with the six science teachers participating in this study. With the permission of the participants, the presentations and workshops were video recorded. Thereafter, we watched the videos, and I asked questions to seek more information and clarity from the participants. Chilisa (2012) argues that one of the limitations of Western-based group interviews is that some members' *voices* are not heard. Contrary to the Western approach, in this study, stimulated recall discussions were done in what Chilisa (2012) refers to as talking circles or sharing circles (Lavallee, 2009).

Sharing circles, in an African context as in this study, are discussion circles formed by Indigenous people around the fireplace or circles during celebrations where people sing and dance and share ideas (Liveve, 2022). “Sharing circles symbolise and encourage sharing of ideas, respect of each other’s ideas and togetherness” (Chilisa, 2012, p. 181). It was hoped that they might provide a platform for further engagements to get a better understanding and in-depth data. In addition, stimulated recall discussions were used to check the accuracy of the observations (Maxwell, 2012), making it a validation technique for triangulation as shown in Figure 4.5 below.

Figure[5] 4.5: Showing the stimulated recall discussions to validate the accuracy of the findings

4.6.6 Journal reflections

According to McMillan and Schumacher (2014), journals are a personal account of the learning experience. Eun (2008) explains that writing reflections in teacher development leads to self-analysis and personal reflections. I am aware that reflective journals are personal artefacts, however, in this study, the participants were asked to keep a journal specifically for this study which would be used mainly for the purposes of the study. I believed that the journals were a powerful source of data, which gave me an in-depth understanding of the teachers’ content knowledge and their understanding of IK and would give me some insights into whether the

[5] All the participants gave written consent for their photographs to be used in my thesis and they requested copies of the thesis which will constitute evidence of their professional development.

teachers saw the relevance of IK in science. I also wrote my own reflections, kept track of the learning process and used my reflections and the teachers' reflections to reflect on the interventions. I have been using journal reflections for my science learners and they have proved to be a powerful tool for teaching and learning (Mayana, 2020). After gathering the data, I then analysed it.

4.7 Data Analysis

Data analysis is a process of reducing data collected to organise it so that it is understandable and makes sense (Cohen et al., 2018). It involves organising, accounting for and explaining the data. Accordingly, Cohen et al. (2018) describe qualitative data analysis as making sense of the data in terms of the participants' worldview and context, noting patterns, themes and sub-themes. In this study, qualitative data was analysed inductively and deductively. Inductive analysis is where the researcher works from specific observations, that is the actual data collected, to generalisations by identifying themes or categories that emerge (Cohen et al., 2018). By contrast, deductive analysis is where the researcher works from generalisations that emerge from the data (Bertram & Christiansen, 2019). For the deductive analysis, we analysed the curriculum documents using Mavhunga and Rollnick's (2013) five TSPCK components (see Appendix G).

In the context of this study, as an attempt to answer research question 1 (which deals with teachers' perspectives on the integration of IK during science lessons), I adapted the criteria from Atallah et al. (2010, p. 48) (see Appendix F). To deal with the second part of the same question (which deals with the teachers' pedagogical insights), I employed the five TSPCK components adapted from Mavhunga and Rollnick (2013) (see Appendix G). To address my second research question, whose focus was co-analysing curriculum documents on waves and sound and redox reactions, the five TSPCK components and the five categories of CAT were used to analyse the data.

To answer my third research question, Vygotsky's (1978) SCT focusing in particular on the constructs of mediation of learning, culture and language, social interactions and ZPD (which helped give *voice* to the community members) was used to analyse data emerging from the workshop discussions between the IKCs and the teachers. The five components of TSPCK were used to answer the fourth question, which deals with possible learning opportunities

during hands-on practical activities on 'kitchen chemistry'. It was hoped that the hands-on practical activities would contribute to the professional development of the teachers.

Lastly, through observations, stimulated recall discussions, and reflections, I was able to note the social interactions and used the five components of TSPCK and the theoretical frameworks to see how science teachers co-developed and enacted their exemplar lessons that integrated IK on the topic of waves and sound and redox reactions to answer my fifth research question.

4.8 Validity and Trustworthiness

Validity has to do with how accurate and credible the research findings are. Validity refers to the extent to which we know that the data collected and presented is believable and accurate (Creswell, 2008; Creswell & Creswell, 2018). To address issues of validity and trustworthiness, I used multiple data-gathering techniques. For instance, I used semi-structured discussions, document analysis, observations, stimulated recall discussions and journal reflections, and these validated the data through triangulation (Cohen et al., 2018). Triangulation is the use of a variety of methods of data collection (Cohen et al., 2018).

In addition, all the presentations, workshops and observations were video-recorded and kept in a safe place for verification, and the participants were given an opportunity to reflect on the videos after we had watched them as a PLC. This ensured the trustworthiness of the data. Furthermore, after the transcription of the videotapes, the scripts were given to the participants to check their accuracy, validity, and trustworthiness – this is what we refer to as member checking (Bertram & Christiansen, 2019; Creswell, 2008). I believe that the stimulated recall interviews and reflective journals also provided rich data which improved the validity and trustworthiness of my conclusions.

In addition, the talking circle or sharing circle approach to conducting stimulated recall discussions contributed to the trustworthiness of the findings as they also symbolised the equality of members in the circle (Chilisa, 2012; Smith, 2012). As noted earlier, sharing circles were used to level the power gradients and show respect to all the participants.

4.9 Ethical Considerations

Before conducting this study, I adhered to the ethical requirements outlined by Rhodes University's Education Higher Degrees Committee. That is, I had to fill in the Ethical Approval

Application form and submit it together with the research proposal. In the application form, I detailed the ethical principles that I would observe during the research process. Among these principles were strategies I would employ to mediate any risks associated with the study, protection of human dignity and respect, confidentiality, validity and trustworthiness of the study.

In addition, I had to obtain the gatekeepers' permission from the Department of Education (Sarah Baartman District), permission from the deputy principal of the participating school (since I am the principal of the school), and permission from all participants in this study. Even though the research focus was not focused on learners, it was significant to engage with their parents as the observed lessons were going to be video recorded, hence assent was obtained from these parents (see Appendices B5 and B6). The consent forms indicated that the anonymity and confidentiality of the learners were guaranteed and that the videos would solely be used for the purposes of data gathering. I obtained all these documents, and I adhered to the ethical principles during the research process. I used reflexivity throughout the study. In this study, various data-gathering techniques were employed (for triangulation) and the evidence of data collected, and data analysed was kept in a safe place to help with the validation and trustworthiness of the study.

Guided by Ubuntu as a research approach, I visited the Indigenous elders in their homes following Indigenous protocols as a way of showing respect to the elders. When I arrived at each home, I thanked the elder in isiXhosa for welcoming me into their home. I then explained the purpose of the study and the role they would play should they agree to participate in the study. In this regard, similarly to Mutanho (2021), I employed the *onozakuzaku* strategy (the consent negotiators sent on behalf of someone), but contrary to Mutanho (2021), I used *ndizizakuzele* (I negotiated for myself) because I felt that I was in a better position to do that (Seehawer, 2018). I felt that it was imperative for me as a researcher to build sound relationships with the elders based on mutual trust (Creswell & Creswell, 2018). I managed to get the Indigenous elders to consent in writing after I had explained everything and answered their questions to their satisfaction.

4.10 Dealing with ethical dilemmas using the Ubuntu perspective

In terms of Eurocentric ethics, the researcher has to speak to a person in private (to ensure confidentiality) to get their permission to participate, which is in contradiction to the African

culture. For instance, when I visited Majeke's home, after giving a brief explanation Majeke stopped me and called his wife and cousins to come and listen and said: "*Nkosikazi khawuzokumamela uCirha ufuna uncedo lwethu, nani bazala, yizani nizokuva ndiyikwekwe enkulu mna*" (He called his wife and cousins boasting that he is respected and was an expert); out of respect for their culture I had to toe the line. Then, I had to repeat what I had told him from the beginning. The decision to participate was a family matter; for instance, Majeke's wife said "*Hayi kaloku tata akukwazi kwala, ade azithobe ngoluhlobo umntwana wabantu*" ([loosely translated] No dear you just cannot say no, look at the respect he gave you). One of the cousins said: "*Injalo mzala wam, akukwazi ukungasincedi isikolo*" (No cousin you cannot refuse to help the school). Then, Majeke said *"Uyavake Cirha, siqala nini"* (Agreed Cirha, when do we start?), and the matter was settled.

Tension arose when I asked him to sign the written consent form as Majeke asked why and seemed to be offended by my request. He motioned in isiXhosa: "*Xandithe ndizakuyenza ndizakuyenza, andiyazike leyokubala*" ([loosely translated] Take my word there is no need to sign anything). I realised that my approach was wrong; I immediately apologised and calmed him down and said: "*Kukulandela nje umthetho waseRhodes bazobona sivumelene, mna ndiyayiqonda ukuba uvumile kwaye siyavana, ngxe Majeke, ngxe Nokwindla*" (I explained to him that is was just formalities and Rhodes University requirements and not that I did not trust him – I called him by his clan name twice to emphasise how sorry I was). After that, he reluctantly signed and said: "*Kufuneka utshintshe lomthetho awungeni kamnandi*" (This law must change it is offensive). It was clear to me that this requirement had the potential of causing Indigenous elders to refuse to be involved especially if they were approached by a novice *Nozakuzaku;* perhaps it is one of the pitfalls the young Indigenous researchers need to take note of. The use of clan names did not only level the power gradient but also helped calm the atmosphere.

Another tension between the WS approach and Indigenous methodological approach is the ethics statement that says, "You can pull out of the study at any given stage if you so choose". This was evident when I visited MaMcirha in her home to ask her to be one of the participants. Since MaMcirha is a married woman, according to the African culture I had to ask permission from her husband, which I did. I said: "*Sbali ndicela udade asincede asifundise okwenziwa kwesonka samanzi, uvumelekile angayeka nangaliphi ixesha ukuba kukho into engamkholisiyo*" (Brother in-law (since MaMcirha and I are related by our clan), we request

your wife's help to teach us how to make homemade bread, she is allowed to withdraw anytime should she so choose). His response was: "*Nisamfunela ntoni xakanti angayeka, ningaske nifune omnye umntu ongazokuyeka*?" ([Loosely translated] If you talk like that, it means you don't really need her help). Again, Ubuntu came to my rescue –, I humbled myself and apologised for the way I had talked and how it sounded; I explained that we needed MaMcirha's help. His response was "*Yitshoke Sbali*" (Just ask for her help brother-in-law, nothing else). Drawing from Ubuntu and being familiar with the cultural ways of doing things as an *umntwanomXhosa* (Xhosa child) helped me navigate what could have exploded in my face even before the study began. This experience revealed to me how insensitive this statement is to Indigenous people, especially the elders; to them, it sounds as if you do not care whether they go all the way or not. Perhaps, this is what led Mazzocchi et al. (2018, p. 29) to conclude that "Integrating WS and IK is not an easy task, because it has to challenge the difficulties of considering different (culturally biased) horizons of meaning and ways of life".

Perhaps the time has arrived for the ethics committee to review such Eurocentric statements, especially when researching with Indigenous people. I was, thereafter, more determined to draw on Ubuntu during my negotiations with the participants. For instance, when I requested their permission to videotape and take photos, I carefully explained that I was going to use those videos and photos only for the study. I explained to them that one of the external examiners of my master's project asked me to blur the pictures or cover the eyes of the participants' photos because of anonymity and confidentiality, even though I had written permission from the participants who were co-researchers in my study to use their pictures. I told them that this was done to protect their identities. In addition, I explained that I was going to use their clan names as pseudonyms during the write-up of my thesis for the same reasons.

The participants had no issue with the use of clan names but had an issue with the covering of faces. For instance, MaMyeka (one of the science teachers) asked a rhetorical question: "*Ingaba nam ndizakuzigquma ngoku sebendibonile eRhodes ukuba sisebenza kunye, andiqondi iright lonto, hayi iyakrokrisa noko, ayingeni kamnadi*?" (Even though I have co-presented with you about our research, do I need to cover my face, I don't think that is fair and correct). This was the general feeling of my participants, especially as we were going to co-create exemplar lesson plans and videotape the lessons enacted by our PLC. To this, I asked if they could kindly put their request in writing so that the ethics committee could see that I had not violated any ethics, but rather respected my participants' wishes. I could sense that they felt that the covering

of faces was an attempt to make them disappear from the study and that all their efforts would be in vain. After long deliberations, I suggested that they write a letter giving me clear permission and sign it so that I had evidence. Fortunately for me, they were more than willing to write those letters on top of the consent forms. Sadly, these kinds of tensions will keep on coming up when we use the Indigenous research paradigm or when we research with Indigenous people. Perhaps it is time for the decolonisation of research methodologies in Africa.

4.11 Chapter Summary

Two workshops on document analysis were facilitated by one of the university lecturers and two other workshops on Lesson Studies by another university lecturer. In addition, I facilitated a workshop on reflections whereby I explained more about journal reflections and used my learners' videos on reflections as a resource to show our PLC how the reflective journals were done in practice. I believe that these workshops contributed immensely to the professional development of the teachers. The co-development of exemplar lessons on waves and sound and redox reactions with the incorporation of everyday language was done using a series of workshops with the participating science teachers. Contrary to the workshops conducted by the Department of Education on the professional development of teachers, wherein teachers are not afforded an opportunity to discuss and engage in the construction of knowledge (Bantwini, 2019), in this study the participants were allowed to interact, discuss and reflect. After enacting the co-developed lessons, participant teachers had to write down their reflections which they shared in the next workshop. This ensured the validity and reliability of the data. Ethical behaviour was observed throughout the research process.

The cycle was as follows: workshop (co-planning), enactment, personal reflection and sharing of reflections. After the workshop, two teachers taught the co-developed exemplar lessons to their respective science classes and the lessons were videotaped with the permission of the teachers to identify how teachers enacted the lessons. Thereafter, the teachers wrote down their reflections which they willingly shared with other members of the PLC. From the sharing or stimulated recall discussions, it was envisaged that some aspects could be improved upon for the next lesson. Data gathered from workshop discussions were used to answer research questions three and four.

CHAPTER FIVE: SCIENCE TEACHERS' PERSPECTIVES, PEDAGOGICAL INSIGHTS AND PRACTICES

> Sharing Circles themselves are traditional communication tools used by Indigenous people (and other cultural groups who have a strong tradition of oral history) to discuss issues and topics in an egalitarian, supportive and non-confrontational manner. They reflect the Indigenous people's values of sharing, supporting each other and respecting life experiences through the use of personal interaction, and group consensus to identify problems and derive solutions. (Rothe et al., 2009, p. 336)

5.1 Introduction

Central to my study was leveraging the use of the Lesson Study approach when working *with* science teachers on how to integrate IK to mediate learning of the topics on waves and sound and redox reactions in a township school. However, I did not want to make any assumptions about the teachers' understanding of IK and their experiences of using IK in their science lessons. For that reason, in this chapter we employed focus group discussions in a form of sharing circles to understand the science teachers' perspectives (Snively & Williams, 2008) on the integration of IK before the intervention. As pointed out in the above epigraph, sharing circles are traditional communication tools used by Indigenous people to discuss issues in a non-confrontational manner.

This chapter thus presents the data generated from focus group discussions (sharing circles) before the intervention and the pre-intervention lesson observations as mirror data (Engeström, 2001) for this research and to answer my research question 1:

> What are the science teachers' perspectives, pedagogical insights, and practices regarding integrating Indigenous Knowledge in science teaching?

In line with ethical considerations and the fact that I wanted all the participants to feel secure and participate freely, sharing circles were deemed appropriate in the context of this study (Rothe et al., 2009). Next, I present the findings from the sharing circles.

5.2 Findings That Emerged from the Sharing Circle

The sharing circle discussions were videotaped with the permission of the participants. I then transcribed the videos verbatim and analysed the data. The data gathered in this phase was critically analysed using inductive data analysis approaches, with the aid of SCT and PCK as analytical frameworks. I used a manual colour coding method to highlight key phrases or terms or concepts. Sub-themes emerged from the data, and they were combined into themes supported by literature and theory (see Appendix M). The analysis of qualitative data generated from the sharing circles revealed different perspectives and pedagogical insights of the science teachers towards the integration of IK into science teaching to address my following sub-research question:

> *1(a) What are science teachers' perspectives and pedagogical insights regarding integrating Indigenous Knowledge into their teaching before the intervention?*

I now discuss each theme below.

5.2.1 Science teachers' perspectives on the integration of IK into science teaching

The following questions were asked of the science teachers:

i. What are your highlights or success stories and your challenges?
ii. Could you please tell me what your views are on the integration of local knowledge into science lessons?

Data collected from the science teachers' answers to the above questions revealed that the six science teachers who participated in this study seemed to be on different levels in terms of their perspectives on the integration of IK into science lessons. For instance, MaMyeka indicated:

> *I have noticed that when it comes to the classroom the teacher sometimes, some teachers will just teach what is in front of them ignoring the fact that these learners have knowledge. I think the problem is linking what they know and what the teacher teaches, those concepts, for example if you talk about fermentation, the teacher does not bring to class the idea or the example of an African beer but he will teach fermentation according to what the textbook prescribes and never*

ask the learners to share their experiences of how this African beer is brewed, thus linking the knowledge they have.

From this excerpt, it could be deduced that MaMyeka seems to have a good understanding about the importance of linking IK and science, what Aikenhead and Jegede (1999) referred to as border crossing. In other words, MaMyeka argued that the integration of IK has the potential to serve as a bridge between home and school science, and thus promotes active participation (Sedlacek & Sedova, 2017). MaMyeka's views resonate well with Seehawer (2018) who argued that IK integration could help the learners move from the known to unknown by bringing in examples that the learners can relate to. Thus, IK could serve as a vehicle to make WS relevant and accessible, which could ultimately be beneficial to the learners.

MaMyeka continued: "*If you are able to link that knowledge, they would be proud of the information that they have because they are the owners and will own the lesson".* Therefore, the learners' worldview should be considered (Erinosho, 2013). In other words, what learners learn from their homes or culture can be used in the classroom as the foundation for learning new concepts, thus closing the gap between the learners' worldview and classroom experience (Nyika, 2017). Such a pedagogical approach could remove the abstractness of science concepts and encourage learner participation in class. As a result, the learners would be co-creators of knowledge and certainly own the lessons. MaMhegeba added:

I agree with MaMyeka that the learners come to school with knowledge from home, but if I as a teacher I don't interact with the learners, I just stand there and tell them not challenging them for practicality because science is all about practicals.

Unlike MaMyeka, MaMhegeba did not elaborate or give examples of how the integration of IK should be done in class. That seems to suggest that she is aware that the learners have knowledge from home, but it seems she is not sure of how to link it with science. This according to Shiza and Emeagwali (2016) results in suppression of the learners' cultural heritage in the science classroom, which could result in poor performance by some learners. Similarly, Madiba indicated:

We have to make our learners understand that science never started today, because we have this mindset that it comes from somewhere else, but it links the culture and local knowledge. For example, the child sees grandfather doing this and that but they don't know the why part. It is our job as science teachers to bring the science knowledge to help the learner understand and grow.

From this excerpt, it seems that Madiba, just like MaMhegeba, also acknowledges the fact that the integration of IK into science teaching has the potential to help the learners see the connection between everyday activities at home and what is learned in the classroom (Gwekwerere, 2016; Taylor & Cameron, 2016). The responses of the three science teachers mentioned above seem to suggest that they might be integrating IK into their science lessons. However, it seems that they are at different levels of understanding in terms of IK integration into science teaching (Stott, 2016).

By contrast, however, it emerged from the discussions during our sharing circle that MaNgconde, Zizi and MaMpehle demonstrated little understanding of the integration of IK in science teaching. For instance, Zizi indicated that: *"In olden day when we were learning the process of learning, you start with a known to the unknown. It is very important that you find out what they know first".* To me, it seemed that Zizi was referring to the learners' prior knowledge from the previous chapter or grade (Mavhunga & Rollnick, 2013) and not necessarily their prior everyday knowledge. Answering the same question, MaNgconde said: *"bringing in IK will help learners pay more attention to little things"*. Lastly, MaMpehle indicated that: *"the young kids in Foundation Phase would be keen to know more and engage their parents at home about what they have learned at school"*.

It was evident from these responses that the three science teachers seem to lack the PCK grounded in IK. Both the South African Schools Act (DBE, 1996) and our CAPS (DBE, 2011) clearly outline the need to provide meaningful learning for all learners from diverse sociocultural and socio-economic backgrounds, but the lagging lies with the implementation in the classroom (Ngcoza & Southwood, 2015), especially in township schools. This makes learning science out of reach for many township learners as reiterated by Mavuru and Ramnarain (2020).

Therefore, it appeared that some form of intervention was required to assist the science teachers. In that regard, a fertile ground presented itself for the co-development of exemplar lesson plans for our PLC. This showed a need for this study whose main goal was to leverage the use of the Lesson Study approach when working *with* science teachers on how to integrate IK to mediate learning of the topics on waves and sound and redox reactions in a township school. To that effect, Seehawer and Breidlid (2021) emphasised that to close this gap there needs to be a dialogue between IK and WS.

5.2.2 Language difficulties and code-switching in the science classroom

The second theme is related to language barriers and code-switching during the teaching and learning of science. The language of learning and teaching in the township school where this study was conducted is English, while all the learners are isiXhosa home language speakers and most of the teachers are also isiXhosa home language speakers. In addition, the teaching resources and the assessment tools are also in English. Chilisa (2012) proffered that language influences the way we think and behave and how we view things. The science teachers' responses to the question: *Please tell me about your experience of teaching science* were recorded and the findings of the study are shared below.

It emerged from the teachers' responses that both English as the medium of instruction and the language of science were inhibiting factors to effective teaching and learning of science. In this regard, Madiba indicated that "*you find that the learners also have a challenge of language, most learners are not equipped with the language in science"*. Scholars such as Lemke (1990) and Wellington and Osborne (2001) have suggested that the biggest barrier to the learning of science is the language of science itself.

If the excerpt from Madiba is analysed, it could be surmised that his learners have a challenge with the language used in science. For instance, he claims that the learners are not equipped with the language used in science, suggesting that this is affecting the learners' understanding and performance in the subject. His claim is backed up by the examiners' reports from the DBE which indicate that most learners, particularly learners from township schools in grade 12 Physical Sciences battle not only with English but with the language used in science.

Correspondingly, MaNgconde emphasised that: *"It's not farfetched it's only that you add these English scientific concepts to what they already know"*. It seems MaNgconde agrees with Madiba as she explained that learners have prior everyday knowledge from home but in class, that knowledge is not used to explain scientific concepts or to construct meaning in science lessons. Digging deeper into the excerpt, MaNgconde argues that science teachers need to recognise the learners' IK when teaching science and suggests that will assist the learners. From these two excerpts, it is clear that the two science teachers viewed the language used in science as problematic for township learners. Therefore, based on these teachers' views it seems English is only linked to WS and not to IK and that poses a challenge. Sedlacek and Sedova (2017) reiterate that there is a close link between speaking and learning.

In addition, three science teachers experienced that the English language is a challenge for the township learners. For instance, MaMhegeba commented: "*Also, they challenge with them as they understand there is a language barrier, so you have to make a language switch from English to isiXhosa"*. MaMpehle added: "*Kufuneka umcacisele ngesiXhosa"* (you must explain it in isiXhosa). Moreover, MaMyeka reflected:

> *Children are not empty vessels, they have knowledge in their mother tongue, the teachers has to make a link between this foreign language English which is a foreign language to them, you then bring in code-switching and make practical examples to bring the subject closer to them, otherwise if you give them platform to explore they will see the practicality of what you are talking about.*

The insights from the above statements seem to indicate that according to the three science teachers' experiences of teaching science the language of instruction (English) poses a challenge for some township learners. This compels them to integrate IK, using Indigenous languages, to help their learners understand. Along the same line the Progress in International Reading Literacy Study (PIRLS) cited in Howie et al., (2016) which assesses reading literacy at an international level revealed that South Africa was placed last out of the 50 countries who participated (PIRLS, 2016). Regrettably, this trend will continue if a transformative CPD approach that is emancipatory in nature is not adopted (Ngcoza & Southwood, 2015).

Further analysis of the three excerpts revealed that the three science teachers used or suggested code-switching as a teaching strategy to mediate learners' understanding of science concepts. This is what Aikenhead and Jegede (1999) referred to as the movement between the micro-culture of the learner's family (IK) and the micro-culture of school science (WS), which must be managed very well for the smooth pathway of border crossing. My analysis in the context of this study is that the science teachers seemed to be in favour of code-switching to close the gap and disconnection between IK and WS for collateral learning to take place (Jegede, 1999).

Indeed, language plays a crucial role in fostering learning (Vygotsky, 1978) and in the context of this study, isiXhosa was used as a cultural tool to mediate learning of science. However, based on my own teaching experience I would caution that code-switching ought to be done systematically as some of the Xhosa terms could have two different meanings in English. For example, in isiXhosa we say "*iyanyibilika"* which means it is dissolving or melting, yet in science, dissolving and melting are two different concepts.

The second example to emphasise my point is "*Iyabila"* which means it is boiling or sweating or fermenting or in a different context it could refer to being angry. Despite the good intentions of code-switching, if it is not managed properly, it could do more harm than good and result in what Le Grange (2007) referred to as cognitive dissonance. Thus, the study recommends that we do away with the traditional transmissive, top-down approaches to professional development that allow teachers to collaboratively find solutions to the challenges they face in their teaching in the form of sharing circles.

5.2.3 Knowledge level of science teachers on the integration of IK in specific topics

Referring to teachers' PCK, Yusof et al. (2012) argued that teachers should have a good conceptual and contextual understanding of the topic they teach before they teach it. Drawing from Yusof et al.'s (2012) assertion, the following questions were asked of the participating science teachers: *Could you please give me an example of any topic in which you think you can integrate local knowledge? Could you please tell me what the advantages are of integrating local knowledge into science lessons?*

What emerged from the teachers' responses is that they seemed to have different knowledge levels of the integration of IK into specific science topics. For instance, MaNgconde responded and said:

> *Also, why do we put in potatoes in water if you have peeled them, why, you have to answer those questions. That would be in redox reactions; in grade 9 we say it is oxidation. The reaction of the peeled potato with oxygen makes the potato to turn brownish.*

MaNgconde's response seemed to suggest that she has a sound understanding of the integration of IK and WS. This is evident in the way she answered the question, that is, by giving a practical example and then relating that to a science topic, that is redox reactions. She went further and explained that in grade 9, the same topic is referred to as oxidation.

Her response clearly demonstrated that she is clear about the science curriculum. Also, her response revealed that one could use easily accessible resources to illustrate a point (Asheela et al., 2021; Shinana et al., 2021) and that IK could be in the form of prior everyday knowledge (Hashondili, 2020; Kuhlane, 2011). From MaNgconde's responses, one gets the sense that she seems to engage her learners during science lessons, which I picked up from, *"Why do we put potatoes in water? … Why you have to answer those questions"* – this talks to her PCK on the integration of IK and her teaching approach. In a similar vein, Madiba explained**:**

In chemistry, grade 10, 11 &12 when you teach endothermic and exothermic reactions. When you explain that an endothermic reaction is a reaction that takes in heat the child will just look at you, but if you start joking by asking how does the mother make a dough at home, the child starts to be curious and try to understand, and you probe by asking questions, they start to be interested.

This excerpt revealed that Madiba seems to be aware of the curriculum just like MaNgconde, but he further explained the relevance of soliciting learners' prior everyday knowledge as reiterated by Kuhlane (2011). For instance, he said, *"The child starts to be curious, try to understand and start to be interested"*. He emphasised the importance of learner interest during the teaching and learning of science.

Lack of interest in science could be one of the reasons for the decline in the number of learners choosing to do science in Grade 10 in South Africa, particularly in township schools. This resonates with Agunbiade et al. (2017) and Sewry et al. (2023) who proffered that the attitude towards science is considered one of the most important affective concepts in science education. It seems that Madiba is stressing the importance of IK in helping the learners move from the known to the unknown (Seehawer, 2018). In this regard, Mukwambo et al. (2014) suggested that the Africanisation of the science curriculum might help township teachers own their cultural knowledge and use it to mediate the teaching and learning of science concepts. Thus, what learners learn from their homes can be used in the science classroom as the foundation for learning new concepts (Nyika, 2017).

The thread that ran through the above two teachers' responses was also evident from the other three science teachers' responses as shown in the three excerpts below:

MaMyeka: If you talk about 'evaporation' or 'condensation' make practical examples for instance of boiling water using a kettle, then they will see what you are talking about.

*Zizi**:** In lightning everybody sees lighting, when you are in class you relate that to what the textbook is telling you, for instance, there is movement of electrons in that process, apart from that they must know that there are dangers associated with lighting so that they may be careful.*

MaMhegeba: Collect vegetables peels dig a hole in the soil and put them there covered with soil. Use that as a fertilizer.

Embedded in all three responses is the teachers' understanding of IK in various science topics. However, it seems that there are gaps in terms of differentiating between IK and WS. For instance, MaMyeka suggested the boiling of water using a kettle and Zizi referred to the use of a textbook. Also worth pointing out is that MaMpehle did not respond to the first question, and

that could be an indication that she does not integrate IK into her teaching. For the science teachers to be able to integrate IK into their teaching they need to be cultural brokers (Simasiku, 2022; Wyatt et al., 2017).

To mitigate this gap our PLC at the school needed to organise a sharing circle and ensure that the ideas were documented, which could then be a resource for the science teachers. It was interesting to hear MaMhegeba, a grade 7 Natural Sciences teacher, mentioning fertilizers which is taught in grade 12. Her response suggested that all science teachers have something to contribute irrespective of what grade they teach.

Responses to the second question revealed that all science teachers in our PLC could tell the advantages or the benefits of integrating IK into science lessons, for instance, MaMpehle noted: *"The young kids in Foundation Phase would be keen to know more and engage their parents at home about what they have learned at school"*. This resonates with De Beer and Whitlock's (2009) view that by integrating IK into science classrooms, the identities of learners are acknowledged and thus learning might be turned into a positive experience. In the same vein, MaNgconde indicated: "*Bringing in IK will help learners pay more attention to little things"*. Answering the same question, Zizi highlighted: *"It becomes very exciting when you bring science concepts using our daily experiences and incorporate it into science teaching".*

Based on the three responses above it seemed that the three science teachers view the integration of IK into science lessons as a stimulant to motivate learners to actively engage during teaching and learning and even at home (Sedlacek & Sedova, 2017). My critique of these responses is that they seem to have fallen short of explicitly highlighting that the integration of IK has the potential to serve as a bridge between home and school science as espoused by Aikenhead and Jegede (1999).

On the other hand, MaMhegeba suggested that "*it is advantageous to talk about IK in science in order to save lives and clear misconceptions"*. She continued and elaborated as follows: "*Science taught me something that I cannot use umhlonyane being diabetic, during the pandermic I could not use umhlonyane because it had an effect of making me more ill because I am diabetic".* In contrast, Madiba responded:

> *On my side, I will start by saying knowledge in Africa throughout has been built on IK and that is passing through from forefathers to our fathers, the disruption came from colonisation, the colonisers disrupted our society. In Africa we were living on IK and never had any problems, the*

colonisers came and forced them to use a certain education type, they created a barrier. We became a product of what the coloniser brought to us.

Nuntsu (2021) argued that the integration of IK promoted argumentation by learners. This implies that the integration of IK could be beneficial to the teaching and learning of science. This was evident in MaMyeka's response when she argued: "*If you are able to link that knowledge, they would be proud of the information that they have because they are the owners and will own the lesson".* In this regard, Kibirige and Van Rooyen (2006) posit that science teaching is enriched when IK is used as prior knowledge in the classroom.

An analysis of the above responses showed that the science teachers who participated in this study seemed to understand the benefits of integrating IK into science lessons. The following benefits emerged from the data:

- Learners would be keen to know more and engage.
- You start with the known to the unknown.
- It could save lives and clear misconceptions.
- It could link IK and WS.
- Learners would own the lessons.
- Learners would pay more attention to little things.
- It would decolonise the curriculum.
- Teaching would become very exciting.

These eight insightful benefits seem to suggest that the integration of IK and WS could be very beneficial for the learners and the teachers.

5.2.4 Science teachers believe that IK enhances pedagogical understanding

Could you please tell me what the disadvantages are of integrating local knowledge in science lessons? Generally, the teachers' responses to this question revealed that they felt that there was little to no evidence of disadvantages of integrating IK in science lessons. Instead, the teachers' general feeling was that the integration of IK in science lessons makes science accessible and relevant to learners. Also, the teachers' responses point to the fact that both IK and WS are needed when teaching science to township learners. However, the study revealed that the teachers felt that there is a need to tap into the cultural heritage of community members

to enhance their PCK on the integration of IK into science lessons. For instance, Madiba gave a detailed response and stated:

> *So, the answer is pure NO there is no disadvantage of integrating IK in science. We have lost our roots. One example, in our village I saw Indigenous elders melting a metal in an oven to make a bow and arrow and other tools. Those people use IK, something has been broken down by the colonisers. I can say if you bring in IK science in Africa things will move in a faster pace.*

Unlike MaMpehle and Zizi, it was clear from Madiba's response that he has been exposed to IK. For instance, he indicated that he has seen with his own eyes elders from his village using IK for survival. However, it seemed that he was not aware that he could use this knowledge before the intervention as he did not indicate that he was integrating IK into his lessons. The possible reason for the lack of integration of IK into science teaching could be the perceived conflict that exists between the worldviews of IK and WS (Botha, 2011).

The second thing that stood out for me from his response is that African people have lost their roots, and something has broken down. In this regard, Seehawer (2018) calls for the decolonisation of the science curriculum at the school level through the integration of IK and reversing the colonial tools that are used to silence IK. Furthermore, scholars such as Cocks et al. (2012) and Smith (2012) view the integration of IK into science as a way of revitalising and respecting culture and restoring the identities of learners, teachers and community members. In this regard, MaMyeka indicated the following**:**

> *It is true we were taught that our elderly because they did not go to formal schools, they know nothing. For example, my father in-law was a traditional healer izulu bekwazi ukulenza (meaning he knew how to make lightning) and was very good getting people off cases, he was very strong with medicine, but now his son my husband did not take any of that information, maybe he looked down on him.*

Similarly to Madiba, MaMyeka witnessed IK in action during her upbringing (Webb, 2013). Her comments resonated with Le Grange (2007) and Ogunniyi (2007a) who postulated that some science teachers still view WS as superior to IK as it is seen as universal and objective. Interestingly, MaMyeka continued and said:

> *Maybe because of modernisation we regard IK as something for people who did not go to school or uneducated people. That is why you will find people who do not do the African beer properly, which is very dangerous. I also believe that if the elders could come and teach us that would help a lot. I don't see any disadvantage of including IK in science.*

MaMyeka seemed to bemoan the fact that teachers who exhibit negative attitudes towards Indigenous science support maintaining the teaching of WS and are conservative gatekeepers (Shizha, 2007). In line with Seehawer and Breidlid (2021), MaMyeka made a call for a dialogue between IK and WS when she said: "*I also believe that if the elders could come and teach us that would help a lot".* So, MaMyeka seemed to join the call made by several Indigenous researchers such as Mutanho (2021) and Seehawer (2021), that the use of IK should be seen as an alternative approach to assist in the teaching of science. In this regard, MaMhegeba explained:

> *There is some confusion when it comes to Indigenous knowledge, but most of the Indigenous ways are still working. I suggest that we invite those elders to come and teach us about Indigenous ways of knowing, for example, about African beer and also in the olden days there were plants that were eaten, but now we do not have the knowledge of those plants. Some people will tell a lie about those plants we need to go to those old people who would tell us about those plants.*

These statements revealed that the science teachers including myself value the cultural heritage of our IKCs. This resonates with Cimi et al.'s (2020) study about Indigenous plants. Secondly, the study revealed that for science teachers to understand IK and gain confidence in integrating IK into their teaching they need the assistance of a MKO (Vygotsky, 1978) on IK-related matters (Cimi et al., 2020) which was the purpose of this study. There was little to no evidence of disadvantages indicated by the teachers. However, MaMhegeba also cautioned**:**

> *Sometimes there are these things called 'irati' (traditional medicine) which were used in the olden days, but now have been found not to be good enough, for example, you would go to the doctor, and he would tell you not to mix those 'ratis' with your medication. So, more research must be done before we take some of the Indigenous ways of living.*

Thus, she cautioned against romanticising IK (Keane et al., 2016; Mhakure & Otulaja, 2017; Mukwambo et al., 2014; Ogunniyi, 2007a). According to MaMhegeba, any misconceptions embedded in IK and cultural beliefs should be identified and corrected (Webb, 2013). This resonates with Mavuru's (2022, p. 3) view that "teachers are considered 'change agents' by virtue of their role in the implementation of the curriculum, which shapes the nature of classroom instruction and curriculum reform efforts". In this regard, this points to the relevance of our PLC in this study and the importance of tapping into the cultural heritage of the IKCs to become cultural brokers (Wyatt et al., 2017)

5.2.5 The use of hands-on practical activities and visualisation

This theme was formulated from the sub-themes that emerged from the following questions that were asked of the science teachers in our PLC:

i. Could you please tell me about your experience of teaching science?
ii. Could you please tell me what your views are on the integration of local knowledge in science lessons?
iii. Could you please tell me what the disadvantages are of integrating local knowledge in science lessons?

Even though the six science teachers seemed to have different teaching experiences, most of them highlighted something about the importance of practical activities in science teaching. In their responses, they indicated the role and importance of hands-on practical activities. This, however, does not mean that they have experience in using practical activities in their science lessons. Some indicated something about practical activities during our sharing circle but there may be a gap in actual implementation in class (Duit et al., 2008). For instance, Madiba responded as follows to the first question:

> *On my side teaching Physical Sciences has always been a challenge, the challenge comes from the fact that at college we were used to doing practical activities throughout trying to master concepts in science, at school there is a lack of laboratory....*

From the above excerpt, it seems Madiba and others like him have a challenge with hands-on practical activities because the school is a previously disadvantaged school with a laboratory, that is not equipped with the tools he has been trained to use. In this regard, Asheela et al. (2021) emphasise the importance of hands-on practical activities and the use of easily accessible learning materials. In a similar vein, MaNgconde added:

> *Science is a practical subject, and it is very enjoyable when you teach it from grade 9 to lower grades, because it is easier to improvise for lower grades, but when you go to grade 10-12 it's not easy to do these practicals if you do not have a lab, you don't have the equipment, and science is not enjoyable anymore.*

In this regard, it could be argued that the teachers' PCK and enacted PCK may be challenged. This could be an indication that they have not been exposed to kitchen chemistry (Sewry et al., 2023) and the use of easily accessible resources especially for senior grades like grade 10 to 12, hence they seem to be frustrated. To support my observation of the two science teachers

who both taught grades 10–12, MaNgconde continued and explained that *"even if you make the learners watch a video it's not practical, it's just a video, they have to touch those things. Practical experience is needed".* Scholars like Asheela et al. (2021) and Shinana et al. (2021) proffer that hands-on practical activities have an important role to play in the science classroom.

According to MaMpehle, learners enjoy science more when they are engaged in hands-on practical activities. For instance, she said: "*The little ones are happy when they are working with their hands"*. Given the fact that MaMpehle is a Foundation Phase teacher, it cannot be denied that she seemed to have experienced the role of hands-on practical activities positively. Concurring, MaMyeka indicated that *"science in the homes of children is everyday practice"*. Thus, based on these comments one can conclude that these teachers see the use of hands-on practical activities as enabling cultural tools to support effective teaching and learning of science (Asheela et al., 2021; Nikodemus, 2017). This resonates with Woodley's (2009) conclusion that practical activities can be very rewarding in terms of meaningful learning provided they are well-planned by the teachers. However, it seems that there is a yawning gap in terms of implementation in science classrooms, thus, a need was identified in this study to capacitate teachers on the use of easily accessible learning materials (Asheela et al., 2021; Kuhlane, 2011).

Also, there was a possible opportunity for IK to assist in this regard, as Madiba said: *"I saw Indigenous elders melting a metal in an oven to make a bow".* Agreeing, MaMyeka added: *"Other than just teaching concepts out of the blue, zenze zibe yi reality bazibone"* (practical demonstration). MaMhegeba elaborated by citing her approach to the teaching of acids and bases in the intermediate phase: *"Through my own research I use cabbage water as an indicator".* To me, these excerpts indicated that these teachers seem to understand how IK can be integrated into science teaching (Seehawer, 2018). However, these teachers did not refer to the topic of waves and sound or redox reactions or give examples of hands-on practical activities in the form of IK related to the two topics of interest in this study. Therefore, there was a need for this study which wanted to explore how IK could be used to support the science teachers to mediate the teaching of the topics on sound and waves and redox reactions as examples using a Lesson Study approach.

In conjunction with the use of hands-on practical activities as a pedagogy, it emerged during our sharing circle discussions that Information Communications and Technology (ICT) could also be used to promote the teaching and learning of science. In the context of this study, ICT refers to the animation videos used to mediate learning in redox reactions as explained in Chapter 9. This also refers to the PowerPoint presentations which is one of the strategies used in lesson presentations. Several scholars support the use of ICT, for example, Halili (2019) argues that ICT has revolutionised various aspects of our daily lives, including education. In a similar vein, Katz and Nandi (2021) proffer that educational videos might offer a dynamic and interactive medium to deliver complex concepts in a simplified and engaging manner. For instance, in this study, Madiba explained:

> *I introduced my IT skills to make science enjoyable, I downloaded videos and incorporated during my science teaching, and I found it great and enjoyable, I can say I managed to break the barrier where science is seen as a killer subject; and today I find it a little great, enjoyable.*

Madiba emphasised that he uses technology to make science enjoyable and thus stimulates interest. The DBE in South Africa encourages the use of technology-based teaching (DBE, 2011). MaNgconde indicated that she makes her learners watch videos to show them some practical activities, which suggests that she feels that ICT promotes the teaching and learning of science. However, she was quick to indicate that "*it's not practical, it's just a video, they have to touch those things. Practical experience is needed"*. In her defence, Nhase (2019) argues that practical activities help learners develop creative thinking and reinforce what has been taught.

Despite the limitations of ICT, it cannot be denied that the use of ICT in science teaching has a place and could help learners with the visualisation of concepts (Katz & Nandi, 2021). For example, for waves and sound, videos (animations) could be used to help learners understand the superposition of waves, which is one of the most difficult concepts to explain. However, my data revealed that only two teachers made mention of the use of ICT to enhance learning in science. This could be because resources in their schools are not adequate or available and if they are, they might not be used to their full potential (DBE Ministerial Committee, 2013).

Alternatively, it could be an indication that other science teachers are not confident in the use of ICT. To close this gap, it is recommended that teacher development programmes for integrating technology be encouraged where PLCs collaboratively design exemplar lessons, enact them and reflect on the lessons (Alshwaikh & Adler, 2017). Such an initiative could be

viewed as a unique contribution of this study, which would empower the science teachers to be able to develop their own technological resources and enhance their PCK. Potentially, that could help with visualisation in developing the conceptual understanding of science learners (Nandjedi, 2022). In addition to sharing circles, pre-intervention lesson observations were done in this study.

5.3 Pre-intervention Lesson Observations

In this study, three phases of observations were employed, namely, pre-intervention lesson observations, participatory intervention observations and post-intervention lesson observations. In this section, I present data gathered during the pre-intervention lessons to help answer sub-research question 1 of this study:

> *1(b) What are science teachers' classroom teaching practices before the intervention?*

The main reason for conducting pre-intervention lesson observations is that I wanted to understand how science teachers mediate learning of science lessons before any form of intervention, which would serve as my baseline data so that it would be possible for me to trace if there were any shifts in these after the intervention. In this phase of the study, I observed and videotaped lessons by the two science teachers (with permission from the teachers) who were participants in this study. The two teachers volunteered to teach the lessons. To analyse data from this phase, I wrote narrative stories for each videotaped lesson, followed by transcriptions of each lesson.

In the next session, I presented the findings that emerged from the two pre-intervention science lessons. Each lesson had a duration of 55 minutes and was taught in the afternoon after school. The first lesson was on waves and sound presented to the grade 10 class by MaNgconde. The second lesson on redox reactions was presented to the grade 11 class by Madiba. Each teacher gave me their lesson plan before the start of the lesson, and I took down notes as I was observing them teaching. Because this was going to be used as my mirror data, I was looking for any form of IK that the teachers mentioned during the lessons. Both teachers used a PowerPoint presentation to teach their lesson.

It emerged from the lesson on waves and sound that MaNgconde focused mainly on concepts such as a pulse, transverse waves, wavelength and period of a wave. She used the examples of cell phones and sea waves. To illustrate a transverse wave, MaNgconde drew a diagram of a transverse wave on a whiteboard and labelled it. She did not use IK-related examples or solicit learners' prior everyday knowledge or storytelling to engage the learners during the lesson. Unfortunately, the lesson lacked demonstrations, visualisation and storytelling which often times help teachers mediate teaching and learning (Mucina, 2011). According to Nhase (2019) and Nhase and Dube (2023), *storytelling* assists the teacher in creating a positive learning environment.

I observed that some learners seemed to be bored because some of them slept during the lesson and those that tried to focus did not interact during the lesson. She gave the learners an opportunity to ask questions, but no one asked any questions. To her credit, she did use isiXhosa as a cultural tool to emphasise the concepts and some learners seemed to respond positively. However, I noticed that there was little interaction between the teacher and the learners. MaNgconde concluded the lesson and gave the learners an activity to do. The activity aimed to reinforce the concepts taught.

The second lesson was presented by Madiba. Similarly to MaNgconde, he also used a PowerPoint presentation. This was an introductory lesson on redox reactions and the teacher mainly focused on concepts. His explanation of concepts was based on WS, and he used animation simulations to illustrate the transfer of electrons which the learners seemed to enjoy. There was no evidence of IK integration during the lesson. Science teachers ought to build on the knowledge that learners bring to class from home and that was missing in Madiba's lesson. He seemed to focus more on the technical language of science, the concepts and equations, which seemed to frustrate his learners as I observed them during the lesson. From this, I realised that teaching approaches need to be related to real-life experiences.

Overall, it emerged from the two pre-intervention lesson observations that the two science teachers did not integrate IK when teaching these specific topics. It is possible that they lacked the necessary resources and support. It is thus the responsibility of teachers to understand their environment, to understand their learners' worldview and to create a culture of learning that suits their teaching environment. It could be argued, therefore, that this research question revealed the need for more developmental support for the science teachers in a township school to improve their teaching approach.

Thus, the co-development of exemplar lessons was needed to empower the science teachers on the integration of IK during science lessons and to produce the much-needed teaching resources. In that regard, this study has the potential to emancipate and equip the science teachers with knowledge and skills that could enhance their PCK, particularly on the integration of IK into their science classrooms.

5.4 Chapter Summary

The data presented in this chapter was meant to answer the research question: *What are science teachers' perspectives, pedagogical insights and teaching practices on the integration of IK in their teaching before the intervention?* The following emerged from the data. Firstly, the six science teachers who participated in this study seemed to be at different levels in terms of their views on the integration of IK into science lessons. For instance, three of the six science teachers seemed to lack the PCK grounded in IK. Secondly, it emerged that English as the medium of instruction and the language of science was an inhibiting factor to effective teaching and learning of science. Thirdly, analysis of the data showed that the science teachers who participated in this study seemed to understand the benefits of integrating IK into science lessons but seemed to lack the PCK to integrate IK. Fourthly, the study revealed that teachers felt that the integration of IK in science lessons makes science accessible and relevant to learners. Fifthly, it emerged that the use of hands-on practical activities and ICT as a pedagogy could also be used to promote the teaching and learning of science. Lastly, the pre-intervention lesson observations revealed that the two science teachers relied on traditional teaching methods (teacher-centred approach) and did not effectively engage the learners during the lesson. Data also revealed that both MaNgconde and Madiba did not integrate IK during science teaching and seemed to lack the PCK required to do so. Thus, data revealed, that indeed, an interventionist study (like mine) was needed to capacitate the township science teachers on the integration of IK during science lessons.

CHAPTER SIX: CAPACITY-BUILDING WORKSHOPS

> We cannot improve schools without improving the skills and abilities of the teachers within them. (Guskey, 1994, p. 9)

6.1 Introduction

The previous chapter explored the teachers' experiences, perspectives, and professional insights concerning the integration of IK into science teaching in a township school. As the epigraph suggests, this chapter presents data from various workshops whose purpose was to arm the science teachers with the knowledge, skills and support they might need (Guskey, 1994). This is in line with the National Commission on Teaching and America's Future (TNCOTAAF, 1996) report which emphasises that policies can improve schools only if the people in them are armed with the knowledge, skills and support they need. I first present data from pre-intervention workshops, followed by data from the intervention workshops.

The aim of the pre-intervention workshops was to:

- orientate the teachers to the study;
- create an empowering environment for the teachers on the use of reflective journals; and
- expose the teachers to the Lesson Study approach and document analysis.

In general, the intervention workshops were aimed at how to support teachers to:

- unpack the curriculum; and
- integrate IK during lesson planning and science lessons.

I first explored the science teachers' interactions, participation and learning during the orientation workshop and pre-intervention workshops by three critical friends to answer research questions two and three. Two critical friends did a presentation on Lesson Studies via Zoom (one university lecturer from Japan and one school principal from Zambia). The third critical friend who was also a university lecturer gave a presentation on document analysis and how to use Mavhunga and Rollnick's (2013) TSPCK to analyse data.

6.2 Pre-intervention Workshops

In this section I present the data generated from the series of pre-intervention workshops which were intended to support the teachers to ultimately develop exemplar lessons that integrate IK in science lessons. The data also helped to answer research question 2:

> *What learning opportunities were created for the science teachers through capacity-building workshops by critical friends before the intervention?*

The data sets generated from each of these workshops are presented in the sections that follow.

6.2.1 Orientation workshop

In this qualitative interventionist case study, six science teachers and I participated in and engaged in a quest to address the main goal of the study. That was to leverage the use of a Lesson Study approach when working with *s*cience teachers on integrating IK to mediate learning on the topics of waves and sound and redox reactions in a township school. To be on the same page as the participants in this study I felt that there was a need to organise an orientation workshop to address certain aspects of the study. The orientation workshop took about two hours and was conducted after school to protect academic time as shown in Figure 6.1 below.

Figure 6.1: Orientation workshop for our professional learning community

During the orientation workshop we addressed the following:

- *The purpose of the study.*
- *The role of each participant.*

- *The research process (stages and duration).*
- *Time frames and venues.*
- *Reflective journals.*
- *Professional learning community and mutual benefits.*
- *Ethics (consent and anonymity).*

Thereafter, participants were offered an opportunity to ask questions and to make comments. Zizi asked a very interesting question: *"What are we expected to bring when we meet as a PLC and why must we give you a written permission because we have agreed to participate?"* Zizi's question resonates with Smith's (2012) view of decolonising methodologies when conducting research with Indigenous peoples. My response to the first part of Zizi's question was that they had to bring their journals, engage during the sessions and indicate whenever they felt that the study was demanding in any way or affecting their teaching experience negatively. I responded in this fashion because I wanted to be reflexive (see Section 1.4) and mediate anything that was going to make them uncomfortable during the research process. To me, the second part of Zizi's question revealed a fundamental tension between the indigenous research paradigm and the Western methodologies of conducting research (Chilisa, 2012; Seehawer, 2018; Smith, 2012). I had to employ an Ubuntu perspective (see Section 4.2.2) and explain to the group as follows:

> *Hayi kaloku Zizi, yinqubo nomthetho wase Rhodes wabapicothi nabaphengululu, nam andiwuginyi ncam kodwa ndiyanyanzeleka, yiyolonto ndifonya umqwazi kuni nangona ndisazi ukuba ngokwakwaNtu imasikizi, kodwa ndiyazigoba mawethu* (No Zizi, I understand that traditionally this is not how we do things, but it is a requirement from the University Ethics Committee, I am appealing to you all to please understand and assist me).

I understood very well that it was imperative for me as the researcher to ensure that I started by building sound relationships with my participants (Creswell & Creswell, 2018) even though I knew that according to our culture asking them for written consent was in a way undermining their culture. I also knew that African people were very generous with Ubuntu. Having said this, I did feel that the Eurocentric approach had handcuffed me and somehow, I felt guilty that I had betrayed my own people in that they had to compromise their cultural stance to accommodate my request. I hope that the institutions of higher learning could review their ethics and accommodate African researchers like me and the African communities in research. It seems that the teachers were not so confident about their capabilities and had mixed feelings during the orientation workshop. For instance, MaNgconde indicated:

> *When we met for the first day, I had no idea what is it that we were going to do. When Cirha explained the purpose of the meeting I was very excited, what excited me was that I had to work with other science teachers.*

Similar views came from MaMyeka who said:

> *I felt a bit nervous and uncomfortable as I am not sure exactly what is expected of us, as we will be working with highly acclaimed people more experienced in the field of science … after the orientation all my fears were put to rest, and I was looking forward to what was coming next.*

MaMpehle echoed this sentiment when she said: *"I felt nervous to be part of the study, but I was excited to learn from what was expected of us".* From these excerpts, however, it seemed that these teachers' feelings and mindsets had shifted after the orientation workshop. To me, this was an indication that the orientation workshop had been necessary and had clarified pertinent underlying issues. From my personal experience, I realised that fear was a negative force that has caused many people to stop trying and caused them to fail.

Based on the above excerpts from the three teachers who taught different phases I could see that there was a need for our PLC. This speaks to the importance of PLC and the sharing of ideas by the teachers at the school level (Feiman-Nemser, 2001) instead of waiting for the Department of Education to organise [6]'microwave' workshops where teachers learn nothing, and their workshops seem to be a waste of time. It is crucial at the school level that teachers establish PLCs guided by Ubuntu principles as alluded to by scholars such as Ogunniyi (2018), Mutanho (2021) and Seehawer (2023).

The study also revealed that the teachers felt valued and their role in the study seemed appreciated. It seems they saw an opportunity to discuss and engage in the construction of knowledge (Bantwini, 2019). This was evident in their journals:

> *I felt honoured to be part of this community of study as I noticed that not everyone was invited. I didn't know what this is all about but as we were taken through, I became excited … at the end of the orientation workshop I knew exactly what my role is and its success depended on me.* (Zizi)

> *I felt honoured and respected to be part of the study. I also felt recognised as a teacher which aroused and took my teaching practise to a more higher level than before.* (MamHegeba)

[6] One size fits all workshops which do not take into consideration the socio-cultural background of the learners.

> *Towards the end of the orientation, I was so anxious and couldn't understand why we have left behind a positive aspect of our identity to be incorporated in science, hence I became excited and curious to discover how can we integrate IK in our science lessons, I decided to take part in the study.* (Madiba)

To me, these comments point to the importance and relevance of a researcher taking his participants through the study. What stood out for me was the fact that the participants became excited to be part of the study showing that they saw value in participation in the study and that they were not forced in any way. Secondly, it became very clear to me that the participants were clear about their roles, and most importantly they knew that their contributions were valued and needed in this study.

The study also revealed that most of the teachers were not familiar with reflective journals. For instance, Zizi wrote: *"I was taught about reflective journals which is very important to have".* Along the same lines, MaNgconde said: *"We discussed the importance of writing a reflective journal after every meeting"*. MaMpehle conceded *"We discussed reflective journals. I was a bit confused because it was going to be my first time doing a reflective journal"*. It emerged from the above excerpts that there was a need for a workshop on reflective journals as alluded to earlier to arm the science teachers with the knowledge, skills and support they needed (TNCOTAAF, 1996).

On the other hand, two teachers indicated that they were using reflective journals. For instance, MaMyeka said: *"Through our informal discussions with Cirha, he has encouraged me to start reflective journals with my learners and I have started using journal reflections".* Similarly, MaMhegeba added: *"I have also introduced reflections in my lessons in class. The orientation taught me to make meaning and essence in all my daily practices".* Long before this study, I shared with MaMyeka and MaMhegeba that I was using reflective journals and I encouraged them to try using them with their learners. It is probable that they were on a higher ZPD and MKO in this regard (Stott, 2016). Based on most of the teachers' reflections which indicated that they were not using or were not sure about how to write their reflections, we agreed that we should arrange a workshop on reflective journals.

6.2.2 Workshop on reflective journals

The purpose of this workshop was to create an empowering environment for science teachers on how to use reflective journals to enhance their teaching approaches. I have been using reflective journals for the past three years and found them to be an effective tool to enhance

teaching and learning (Mayana, 2020). For instance, I discovered that reflective journals afforded all the learners an opportunity to express their views and thoughts informing the teacher of the next step to take. Initially, I had planned to request my learners to come and explain to the teachers how to write the reflections. My reason for wanting to use the learners was that I have trained my learners on how to write their reflections and they were at this stage doing well.

Most importantly, my learners seemed comfortable sharing this new knowledge with others (they had been presenting it to other learners as well). However, despite the learners' willingness and consent from their parents, I opted to use the two videos that we had recorded in which two grade 10 learners were reflecting (a boy and a girl were video-recorded reflecting to the class as shown in Figure 6.2 below). The videos had been recorded while the two learners were doing grade 10 and they were now doing grade 12, continuing with reflective journals. We watched the videos as a PLC and thereafter we discussed them. It emerged from the discussions that the teachers seemed to have learned from the learners. This is a unique contribution of this study, using learners' videos as double stimulation to highlight the importance of a reflective journal. For instance, MaMpehle said:

> *The challenge I had before watching the video, I did not know how to start my reflective journal, but the videos made it easy for me, in terms of sharing my thoughts, insights, feelings, emotions and ideas, so I was able to start.*

She was supported by MaMhegeba who said:

> *As I watched the video of the learners giving feedback on their study, I pointed that the learners became part of the lesson, and the journals encouraged them to master certain skills like listening, reading, recording, writing, speaking etc.*

MaMhegeba added a profound comment: *"Lastly, a journal is you, meaning that you write your own observations and experiences".*

Figure[7] 6.2: Learners reflecting to the teachers (pictures taken from the videos)

It seems that the learners' reflections had an impact on teachers' perspectives on and insights into journal reflections. MaMyeka pointed out: *"I have noticed that these reflective journals play a major role in offering learners the opportunity to voice out their opinions"*. It seems that MaMyeka had a revelation after watching the videos about the role that reflective journals play during teaching and learning. Lending support, Madiba said:

> *After we have seen Grade 10 learners reading their reflective journals in a video format, it became clear that as educators we can get to understand if the learners understood the lesson that was taught.*

In both cases, it seems that the teachers viewed the use of reflective journals as an effective tool for both the learners and the teachers. The finding of the study is that teachers learned from the learners and their pedagogical insights were affected positively. The fact that teachers learn from the learners contributes to new knowledge because traditionally in township schools it is expected that learners learn from the teachers and not the other way around. Also, the use of ICT instead of exposing learners adds to the uniqueness of this study. After the reflections workshop, the next two workshops were on the Lesson Study approach.

[7] Both these learners consented to their videos on their journal and their photographs to be used in this thesis. Worth celebrating is that both these learners obtained their Bachelor pass, and each achieved two subject distinctions in the 2023 Matric examinations. Also, when I got promoted as a Circuit Manager, the learner who is a girl in the photograph congratulated in a WhatsApp and said: "I wish you all nothing but the best tata on the journey that you are still yet to walk or discover, ALWAYS REFLECT ON YOUR REFLECTIVE JOURNAL, I also do so, you better keep up daddy" (31 July, 2024).

6.2.3 Presentations on Lesson Studies

Two virtual presentations were conducted by two different critical friends. Thanks to Ubuntu, Gxarha (my supervisor's clan name) organised the two critical friends who presented the workshops and hosted the two workshops because we had challenges with our Zoom account. The presentations were done using Zoom because the presenters were from different parts of the world. According to Goodchild and Ronning (2014), the use of technology in teaching will "offer interesting options when it comes to adapting to students' varying backgrounds and motivation" (p. 398).

The first presenter was a university lecturer (pseudonym in this study - Sensei) from Japan and the second presenter was a school principal (pseudonym in this study - Inqununu) from Zambia. Initially, we requested my co-supervisor from Japan, but he referred us to Sensei since he was a specialist in Lesson Studies. The rationale for having two presentations was that we wanted to hear from someone from Japan where Lesson Studies originated (Fernandez, 2002; Ono & Ferreira, 2010). We also wanted to get an African perspective on Lesson Studies (Cordingley et al., 2004). It was hoped in this study that the Lesson Study approach would be in the form of teacher professional development for our PLC that involves a cyclic process of lesson planning, collaboration, and reflection (Adler, 2017).

6.2.3.1 Presentation by Sensei

The presentation by Sensei took more than three hours. In his presentation, Sensei explained that in Japan the Department of Education has various districts as is the case in South Africa. Each district organises a group of retired education experts such as university lecturers, school principals with proven track records, and educators who are specialists in various subjects and form a District Team (DT) which looks at various subjects voluntarily with no remuneration. The DT plans and co-designs lesson plans which they present to teachers who in turn, after intense discussions, would be expected to teach the lesson to their learners. He explained that this approach was effective because the DT members were education experts, meaning that the teachers did not have to waste time and start afresh designing lessons. This also saved the department and schools some money as they did not have to hire people to train teachers, especially novice teachers. In addition, the quality of the lessons was of the highest standard. Below are pictures taken during the virtual presentation.

Figure 6.3: Showing our PLC listening to Sensei

According to Sensei, there are three layers to the curriculum, namely the intended curriculum (which refers to the National Policy), the implemented curriculum (which refers to what teachers teach in class) and the achieved curriculum (which refers to what learners learn and what learners achieve). He emphasised the importance of closing the gap between the three layers. Addressing the question of how we bridge the gap between the three layers, he gave us an activity to do as a group. In the activity, we had to identify a challenge we all experienced in class. Madiba took up the challenge and responded as follows: *"There is a challenge of integrating IK when we teach science."* MaMhegeba said: *"Learners had gaps in content from previous grades."*

I noticed that at this stage of the group discussion, the level of engagement was high. MaMyeka noted: *"We as teachers do not take into consideration the prior knowledge from home or society but we only focus on the prior knowledge from the previous grades"*. This is my critique of Mavhunga and Rollnick's (2013) TSPCK which views learners' prior knowledge as knowledge from previous grades and ignores knowledge that learners bring from home. Kuhlane (2011) refers to what learners bring from home or community as prior everyday knowledge.

Another challenge cited by MaNgconde was the language barrier in terms of the language used at home versus the language used at school, what Tyeda (2024) views as a mountain between home and school, which results in cognitive dissonance (Le Grange, 2007) (see Section 1.3). I observed that ideas were flowing as the teachers were identifying various challenges and gaps

in the curriculum. Then Sensei asked us to suggest how we thought we should deal with these challenges as teachers. After a pause, he rephrased his question and asked: *"How do you hope to improve your lessons given all the challenges you cited?"* He then suggested that we should (i) focus on the lesson; (ii) critically analyse the lesson; (iii) identify strengths and (iv) identify opportunities for the integration of knowledge such as IK. Then he elaborated on the Lesson Study. He indicated that a Lesson Study was a cyclic process and emphasised that it was not a single cycle. From the Activity that Sensei gave us I learned that he used a practical approach to teach us how the Lesson Study approach should be employed. Sensei illustrated the circle as shown in Figure 6.4 below.

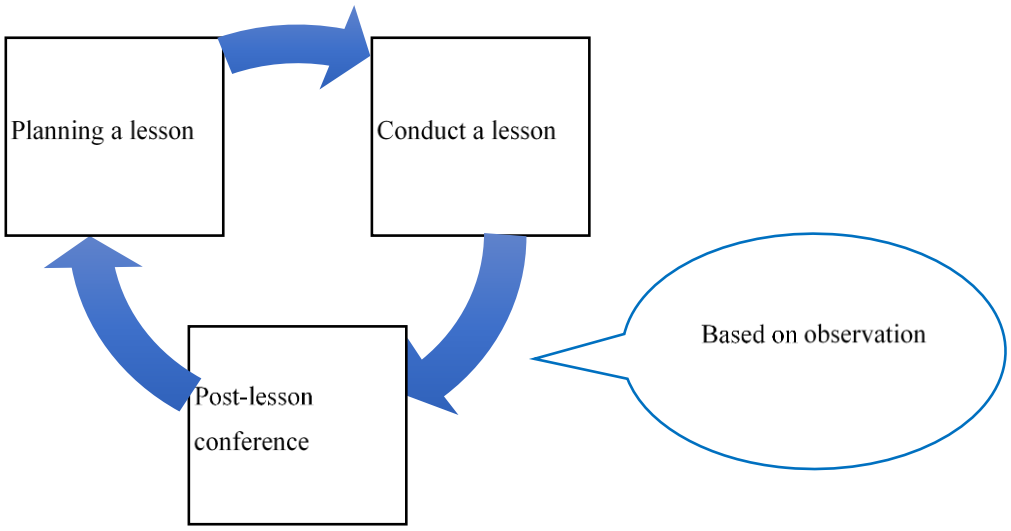


Figure 6.4: Showing the process of the Lesson Study was illustrated by Sensei

Sensei outlined the following key elements for a Lesson Study approach to work well:

- Lesson Study approach is a peer-learning process.
- There must be an element of trust among the teachers.
- Lesson Study is not for the evaluation of teachers.
- There should be no critique of others but constructive comments or feedback to be given.
- There needs to be a reflective space after the lesson.
- There should be support for teachers who try new teaching methods such as the integration of IK.
- Through Lesson Study teachers share best practices.
- In observations teachers must focus on learners.

- Teachers should build learning communities, involving community members.

Since the study was also interested in tapping into the cultural heritage of IKCs to enhance the teaching and learning of science, we asked Sensei to explain how they went about involving community members in Japan. He explained that in Japan a community meeting was called where you gathered teachers and parents in a hall. Then community members were asked to conduct activities. The integrated learning programme results in promoting students' understanding of their local history. He emphasised that community members took the lead in such programmes.

Teachers seemed very interested and seemed to appreciate the Japanese approach. For instance, MaMhegeba said: *"How I wish to invite local stakeholders to come and share Indigenous knowledge to lessons where Indigenous knowledge is needed".* In a similar vein, MaMyeka said: *"This approach is not too farfetched; we could do it here at school".* Madiba echoed similar sentiments: *"It is time we get community elders involved so that we can learn our African ways of doing things".* The teachers' views are in line with Seehawer and Breidlid's (2021) point of view that quality education needs to be responsive to students' epistemically diverse life realities. Indeed, IK holds affordances for the conceptual development of learners in the science classroom since this cultural knowledge often serves the formal curriculum concepts well (Cronje et al., 2015).

More interesting were the benefits of the Lesson Study. I observed that Sensei was very passionate about the Lesson Study approach to teaching. He highlighted the following benefits of a Lesson Study:

- breaks the isolation of teachers;
- improves teaching skills;
- enhances content knowledge;
- allows for sharing of good practices; and
- personal and professional development.

We found his presentation very compelling and informative. It emerged from the reflections that Sensei's presentation proved to be of value to the teachers and they seemed to be empowered during the presentations. For instance, MaMyeka said:

It is my first time to hear about the Lesson Study approach and I find it very interesting, I think we should try it, I think it is going to help us to become better teachers when we assist each other.

MaMyeka's comment resonates with Feiman-Nemser's (2001) assertion that a well-designed PLC programme serves to broaden and extend teachers' SMK and refine their PCK, thus confirming the relevance of our PLC in this study. Lending support, MaMpehle echoed similar sentiments and said: *"Mna ndiyavuya ukubakho apha ndizokufunda ngale* method *inika umdla kakhulu, isifundisa indlela engcono yokusebenza singotitshala"* (I am happy that I am part of this study so that I could get an opportunity to learn about the Lesson Study approach; it's teaching us a better way to work together as teachers). Agreeing with other teachers, MaNgcode said: "*Izakuba ngathi sicula iculo elinye*" (it will appear as if we are singing the same song). Notably, at the core of any PLC is collaborative learning (Chauraya & Brodie, 2018). In that regard it seems that the presentation created learning opportunities for the teachers such as getting exposed to the Lesson Study approach for the first time and learning the benefits of working in teams and not in isolation.

6.2.3.2 Presentation by Inqununu

Before one introduces a new approach, one should consider the contexts of the participants. In this study, we felt that it would be more appropriate if we listened to someone from Africa who had used the Lesson Study in order to learn how they introduced the Lesson Study approach and share the lessons learned. Gxarha gave me the contact details of a school principal from Zambia (*Inqununu*). After communicating via email, we agreed on a date and time for the virtual workshop. The workshop was done through Zoom and attended by the science teachers, Gxarha and me. We experienced network challenges because of [8]load shedding and had to call off the meeting. These are some of the challenges and realities we are currently faced with in South Africa. We arranged for a second date and by the grace of God the second meeting was a success.

Inqununu opened his presentation with a Zambian phrase *"Imithi ikhula enphanga"* which means trees that are growing are a forest of tomorrow. He indicated that the commitment of the CoP (Lave & Wenger, 1991; Wenger, 1998), was a way to ensure that teachers (trees) grew

[8] The South African energy crisis or load shedding is an ongoing period of widespread national blackouts of electricity supply. It is an energy utility method of reducing demand on energy generation by switching off the distribution of energy to certain geographical area. Load shedding has had a negative impact on business and livehood for the majority of the people in South Africa.

and the learners as beneficiaries also grew (the forest). He emphasised that in Africa the Lesson Study approach would only work with our own traditional lifestyle. Before going into details on how they employed Lesson Studies in Zambia he indicated that we should be aware that the Lesson Studies approach was a group failure or group success. I got a sense that he wanted us to understand the importance of the PLC in Lesson Studies. After this introduction, *Inqununu said*: *"Before you start the LS [Learning Study]resources are needed" and* that "*Leadership is key in sustaining Lesson Studies practically at all levels".* He elaborated further that in Zambia they have learned that five essential elements were key for the successful implementation of Lesson Studies:

- consider your own context (Lesson Study in Africa will only work within our own traditional lifestyle);
- the teacher-teacher relationship is very important;
- management providing space for teachers-teacher relationships to grow is key;
- involvement of parents in education at the school level; and
- learner reflections are important.

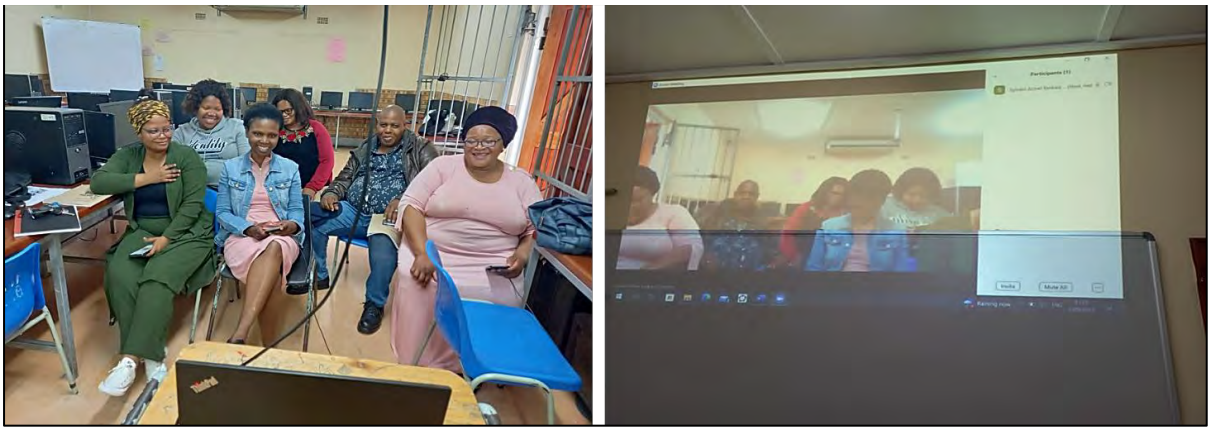


Figure 6.5: Showing our PLC enjoying Inqununu's presentation

Inqununu indicated that the Zambian perspective of Lesson Study infused into school practice had eight aspects:

- define or identify the problem;
- plan the lesson;
- conduct the lesson;
- review the lesson;

- plan the lesson again (replan);
- conduct the revised lesson;
- review the lesson again; and
- compile the lesson (look at the challenges).

After this, he outlined the challenges and highlights of Lesson Studies in Zambia. For instance, he mentioned the historical challenge of monitoring and evaluation. In this regard, he explained that some teachers viewed LS as a tool to police them. The second challenge he indicated was related to resources, where the funding was inadequate. Herein lies the importance of using easily accessible resources. Referring to highlights, Inqununu indicated that through LS they were able to outline the culture of the school from an African perspective.

Also, LS together with an African way of life helped the learners appreciate their culture and their identity as Africans. He explained further that in his school they invited parents to share knowledge with the teachers in the form of staff development workshops and empower teachers on local skills, thus training teachers in how to integrate IK during lessons. It seems that Inqununu's presentation was well received by the teachers and the teachers' reflections revealed that many learning opportunities were created during the presentation. For instance, on the teacher-teacher relationships, MaMhegeba said:

> *When Outcomes-based Education (OBE) was introduced, OBE was in for Cluster meetings, helping each other, we somehow lost that … I think we should go back as learning area teachers in our phases assist each other in planning.*

Concurring, MaMyeka suggested, *"Team teaching should be encouraged and strengthened, we should visit each other during lessons"*. She further explained:

> *For instance, the grade 4 teachers should sit together and not work in isolation. This presentation has opened my eyes in terms of classroom visits by other teachers, I had an attitude feeling that they are disturbing me, but now my attitude has changed.*

Lending support, Zizi suggested: *"The entire science teachers in our school from grade 4 to 12 should come together, analyse the syllabus, to see how the topics link to each other*". Madiba identified another problem: *"We usually blame the teachers from the lower grades, maybe the problem is that we do not know how to take it further and assist the learners."* To this end, MaMpehle said: *"Into ezakunceda kukuba otitshala bancedane, xa omnye engayifundisi kakuhle acele omnye ambonise"* (what was going to help was that teachers should assist each

other' if one teacher is battling with a topic or unclear, others should show him or her how to teach it). MaMpehle said: *"As a grade 2 teacher I need to get an opportunity to visit the grade 1 class and observe so that I can learn from those teachers and improve my teaching approach to help learners".*

This speaks to the second element necessary for the successful implementation of LS mentioned by Inqununu, that management should provide space for teacher-teacher relationships to grow. I found these comments by the teachers very interesting as they seemed to point us in the right direction as the PLC, because central to a PLC is co-learning which is one of the objectives of this study (Wenger, 1998). The above comments also seemed to open up space for teachers' CPD, which according to Ngcoza and Southwood (2015) is central to any educational reform as it is believed to be a way of improving teachers' knowledge of teaching and learning. The study revealed that the teachers viewed the teacher-teacher relationship as a crucial aspect of professional development. They seemed willing to share their collective experiences to improve each other's ZPD and PCK. During my observations after the presentation, the teachers seemed to relate more with *Inqununu*'s presentation as they commented that he was practical (Feiman-Nemser, 2001). Also, the level of engagement after the presentation among the teachers seemed to be at a higher level. It was inevitable that the next workshop should be on document analysis.

6.2.3.3 Presentation on document analysis

A workshop on document analysis was conducted by a university lecturer, Ndlovu (clan name). I introduced Ndlovu as one of my brothers in our CoP at Rhodes University under the leadership of our supervisor Gxarha (his clan name) and we have worked together for four years. The presentation started in the morning and ended late in the afternoon and was videotaped with Ndlovu's permission. I was inspired by Ndlovu's introduction:

> *I am here as a co-learner because I am also going to share my learning experience because I did my PhD last year at Rhodes University, currently I'm at the University of Fort Hare. There are some learning experiences that I learned that I thought I needed to share with you guys. So, there are two things that I intend to do, I am briefly going to look at two theories, the main theory is by a man called Shulman then I will look at another theory by two scholars from South Africa, they are Elizabeth Mavhunga and her supervisor Prof Rollnick. Also, we will look at the components of the topic-specific pedagogical content knowledge (TSPCK) which is a tool that we will need to analyse the documents. But first we will take a brief look on the work of Vygotsky and Piaget. Finally, we will together analyse some curriculum documents.*

Figure 6.6: Ndlovu interacting with the groups during document analysis

After this brief introduction, Ndlovu stated that by training he was also a teacher and then asked the question: "*What separates a teacher from any kind of profession*?" Below are the responses that were given by the teachers. Mangconde stated: *"A teacher learns continuously."* To me this response resonated with the aim of this study, which was to promote the use of the Lesson Study approach when working with science teachers on how to integrate IK into mediate learning about waves and sound and redox reactions in a township school.

Zizi said: *"I think that what separates a teacher from other professions is that a teacher is that person that helps others to learn".* Similarly, MaMpehle said: *"The most important thing about teaching is that teachers pass down skills and knowledge".* To me, these two responses seemed to point to Mavhunga and Rollnick's (2013) topic-specific PCK (TSPCK) which can transform specific content such as waves and sound, and the redox reactions into a way that is understandable to learners at a given level and context (Shinana et al., 2021).

On the other hand, MaMyeka distinguished a teacher from other professions as someone with greater responsibility: *"A teacher is a multi-purpose; teachers can identify psychological and socio-economic problems that children face thus making teachers to also be social workers."* Madiba added: "*A teacher's job is to be flexible because you just mentioned that an engineer cannot teach the children that we teach but we can produce engineers from those children".* These comments resonate with Darling-Hammond's conclusion that for the education system to produce engineers, doctors and accountants, teachers need to teach much more effectively,

especially those learners who have been least well supported (township school learners) by the education system. This confirms the relevance of my study.

Ndlovu acknowledged the teachers' responses and said: *"So, a teacher in a nutshell is a mother of all professions"*. I think the teachers' responses gave Ndlovu an angle that he was looking for, namely that of introducing Shulman's (1986) theory. From this point, he continued with his presentation and introduced Shulman's theory. Shulman argues that for teachers to be effective teachers they need to possess specialised knowledge; you can have the knowledge of mathematics, but it needs to be specialised which enables you to break down the knowledge that you have and package it in pieces in such a way that it is accessible to the learners. He called this PCK – Pedagogical Content Knowledge. PCK is the knowledge of how to teach. To be able to transform subject matters into teachable units that are easily accessible to the learners, the teacher has to think through the knowledge of the content and break it down into teachable units that are comprehensible to the learners. A teacher has to reduce knowledge to a state that can be understood by learners, which includes:

- The metaphors that you use;
- The diagrams that you use; and
- The pictures/illustrations.

Ndlovu elaborated further and said:

> *But the important thing is that the teacher can create bridges between the learners' understanding and the desired outcomes. You guys operate with the CAPS document that tells you exactly what you want to achieve, but those outcomes cannot be achieved unless you are able to create those bridges.*

I observed that the teachers were listening attentively and seemed interested in Ndlovu's presentation. He said:

> *Ball et al. (2008) added that it is through repetition of this experience of turning over the ideas to be in one's head that teachers gain their wisdom of practice. So, experience is a cumulative experience of enabling that enables the teachers to easily transform subject matter into simplified form that can be easily understood by learners. Petrou and Goulding (2011) preferred to regard PCK as the art of knowing how to teach that is linked to and situated in the art of teaching which is an integral part of teachers' general knowledge.*

In simple words, Ndlovu emphasised that PCK was the knowledge the teacher uses to make decisions as they teach (Mutanho, 2021). This resonates with the goal of this study, which is to support teachers in developing such knowledge about the integration of IK in science lessons. At this point, Ndlovu swiftly changed gears and said:

> *Piaget says that if learners were to be put in a conducive learning environment, they are able to manipulate objects and things that are in the environment until they discover for themselves. The keyword about Piaget is discovery. On the other hand, Vygotsky says if I take a class grade 11 to the science lab following this argument, they will drink sulphuric acid because you would have allowed them to discover for themselves, they need someone to be helping them to learn. Vygotsky emphasises the human element and that there is need for another person who is more knowledgeable to come and help these learners to discover, so Vygotsky talks more about guided discovery.*

Ndlovu emphasised that both theories were constructive because they believe that learners can construct their own knowledge. He continued:

> *Vygotsky now then says that these learners have what you call ZPD. In scaffolding what you do as a teacher, you first find out what the learners can do you then give them a task and they gain experience. You as a teacher must create an opportunity that those children who are more knowledgeable to scaffold others to another level.*

I noticed that most of the teachers were nodding as Ndlovu was explaining which could be a sign that they agreed with Ndlovu. I personally learned a lot from Ndlovu's presentation, and it dawned on me based on the way he presented that a teacher is always a teacher.

He explained further that other scholars, such as Mavhunga and Rollnick (2013), extending Shulman's seminal work, argued that knowledge of a particular subject and how we teach a particular subject is not the same. Ndlovu simplified it and said:

> *As we are here, we do not teach in the same way, everyone has their own way of teaching. A teacher does not have uniform knowledge of how to teach but a teacher has got appliance, a specific type of knowledge of teaching a particular type of topic.*

Ndlovu further explained:

> *Mavhunga and Rollnick identified the following aspects saying that the beliefs that you will always be a teacher about students context, about students' knowledge, about content knowledge, about methodological content knowledge is very important. You as a teacher what you believe about the children of Khayelitsha determines how you teach them. So, they said that a teacher breaks down the content through looking at five components which are: Learner Prior Knowledge; Curriculum Saliency; What is difficult to teach; Representations; and Conceptual teaching strategies.*

As alluded in Section 3.3.1 the above five TSPCK components were used in this study to assess how the participating science teachers transformed the SMK of a specific topic in a way which was understandable to learners at a given level and context (Mavhunga & Rollnick, 2013). Ndlovu unpacked these five components of the TSPCK. Thereafter, he facilitated the actual document analysis as shown in Figure 6.6 above (see Appendix J, Figure 6.7). The data gathered from the document analysis are presented in the section below.

6.2.4 Data from co-analysing curriculum documents

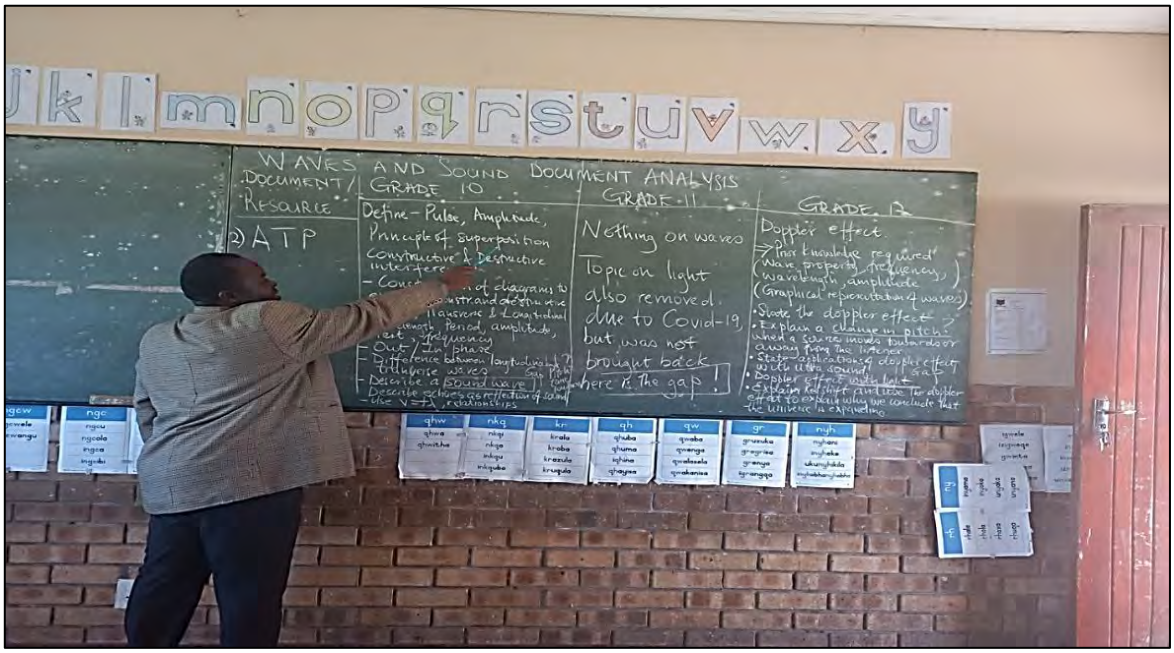
During document analysis, Ndlovu advised us to work in two groups and I was doing participatory observation. Each group nominated a scribe who wrote down the ideas of the group during discussions. The ideas were recorded on newsprint as shown in Appendix K. Ndlovu moved around observing and guiding each group on how to use Mavhunga and Rollnick's (2013) TSPCK tool. The main aim of this exercise was to actively engage the science teachers in learning what was entailed in those documents and to provide them with an opportunity to assist each other in how to find ways to integrate IK and WS during their lessons and co-developing exemplar lessons.

We analysed the Curriculum Assessment Policy Statements (CAPS) document, the Annual Teaching Plans (ATPs) and two different textbooks from grades 10, 11 and 12, using the TSPC components as an analytical lens. During the co-analysing phase, I observed that the teachers were finding the TSPCK tool very helpful in analysing and unpacking the aforementioned documents. Three themes emerged from co-analysing curriculum documents:

6.2.4.1 Enabling science teachers to identify content gaps between grades

During the analysis of the curriculum documents, we identified that there were gaps in the content taught from grades 10 to 12. For instance, in the topic on waves and sound there seemed to be no coherence from grades 10–12 and gaps in terms of content knowledge as shown in

Figure 6.7 below. This gap in the curriculum was a revelation to the teachers as teachers did not know what was being taught in previous grades as shown in the diagrams below.



Figure[9] 6.7: Showing Madiba presenting to our PLC the data analysis of his group

Data show that the co-analysis of curriculum documents enabled science teachers to see the gaps in the curriculum and gave them an opportunity to try to close those gaps during lesson planning as shown in the excerpts below from the teachers' reflections.

> *The workshop on document analysis helped me in a way that when I prepare my lessons I also look at what was done in the previous grade and what is going to be done in the next grade.* (Mangconde)

> *I found the workshop very interesting because as a Foundation Phase teacher I was not aware of the content gaps that were identified at FET, I have learned so much.* (MaMpehle)

> *My take on the presentation is that education is not disjointed wherein each teacher teaches in his/her compartment. Document analysis allows us to know what is taught from grade to grade, which concepts need to be emphasised.* (MaMyeka)

[9] Madiba consented for his photography to be used and has requested the of the thesis for purposes of his professional development.

The findings in this study show that if science teachers could engage more with the curriculum in their PLCs and understand the gaps, they would be able to assist learners better. This resonates with Feiman-Nemser's (2001) conclusion: "If we want schools to produce more powerful learning on the part of the students, we have to offer more powerful learning opportunities to teachers" (p. 1014).

6.2.4.2 Enabling science teachers to understand the necessity of integrating IK into science lessons

The data revealed that science teachers were enabled to understand how to integrate IK into science lessons as evident in the teachers' comments below. Mangconde said: *"I have found out that the textbooks do not accommodate the IK, there are few of them that have examples that include IK".* Similarly, Zizi said: *"I have learned that our textbooks are not integrating Indigenous knowledge with science".* Sharing the same sentiments Madiba elaborated: *"It was surprising to figure out that from the textbooks even pictures were not accommodating prior knowledge and the gatekeeping concepts were not even noted from the ATP. As Africans we have to transform the way we teach".*

It was interesting to observe that at least three teachers noticed the absence of IK in our textbooks. To me, this suggested two things: one, the workshop on document analysis and how to use Mavhunga and Rollnick's (2013) TSPCK as an analytical lens seemed to have benefitted the science teachers, and two, it seems that there had been a shift in teachers' PCK in terms of understanding of IK integration in science. This was also evident in MaMyeka and MaMhegeba's comments. MaMyeka said: *"Document analysis helped me in making learning meaningful to every child not forgetting to tap on from what they bring from home."* MaMhegeba said: *"I have learned that IK plays a vital role in the development of the learning curve and the importance of community members in teaching".* It seems that teachers benefitted from these capacity-building workshops (Seehawer, 2018). This could help reverse the gloomy picture painted earlier in chapter one of this study.

6.2.4.3 Active engagements stimulated learning

Data shows that the science teachers were learning from each other and helped each other to unpack the curriculum (Feiman-Nemser, 2001). For instance, the excerpts below show that active engagement stimulated learning. MaMhegeba said:

> *Analysis of CAPS versus textbook used in schools challenged me to look at my own planning more deep with thorough research before presenting any lesson. … The workshop provided an opportunity for sharing of information between modern and old teachers.*

In a similar vein, Madiba said: *"Eventually I figured out that I was not familiar with gatekeeping concepts and curricular saliency. I became excited and willing to discover more things that will empower me moving forward in my teaching career".* It seems that the document analysis opened the eyes of these science teachers and that they seemed keen to learn more from analysing more topics. Likewise, MaNgconde said: *"After the document analysis I was very curious to check in other topics comparing other topics in other grades".*

I argue that the power of teacher preparation for transformative teaching and learning resides in PLCs and the Lesson Study approach in township schools. For instance, MaMyeka explained: *"I feel more empowered and enlightened and the fear of being judged by the next teacher is now less, as he/she will know what was expected to be taught from the previous grade".* Similarly, MaMpehle said:

> *The challenge I had was looking at grade 10 documents since I am a Foundation Phase teacher, some of the concepts that they were using I was not familiar with them, but Ndlovu and Mangconde helped me and explained them to me.*

At the heart of the PLC is collaborative learning as alluded to earlier in this study. Zizi said: *"I have learned that in order to come up with the best information from the textbook, I have to use different textbooks and analyse them. I have learned the tools used to analyse documents".* It could be argued that with more active engagement at the school level, there could be a positive shift in teachers' PCK. Thus, the mediation of teaching and learning of science could be more effective.

6.3 Chapter Summary

This chapter provides the data gathered during the pre-intervention and intervention workshops. Data revealed that the Ubuntu perspective was employed during the workshops to deal with tensions between IK and WS. The study also revealed that most of the teachers were not familiar with reflective journals. The finding of the study was that teachers learned from the learners and their pedagogical insights were affected positively. This contributes to new knowledge in this study, using learners' videos as double stimulation to highlight the importance of a reflective journal.

Data revealed that presentations on Lesson Studies seemed to have empowered the science teachers and seem to have opened up many learning opportunities for our PLC. Additionally, it emerged that the presentation by our critical friend on document analysis seemed to have opened up space for teachers' CPD as they worked in groups co-analysing curriculum documents and learning from each other. Data shows that co-analysis of curriculum documents enabled science teachers to see the gaps in the curriculum and gave them an opportunity to try to close those gaps during lesson planning. Also, data revealed that science teachers were enabled to understand the necessity of integrating IK in science lessons during document analysis. General findings in this study show that if science teachers could engage more with the curriculum in their PLCs that could contribute positively to refining their teaching practices.

CHAPTER SEVEN: TAPPING INTO THE CULTURAL HERITAGE OF INDIGENOUS KNOWLEDGE CUSTODIANS

> Cultural brokers are able to interpret symbols from one frame of reference to another, can mediate cultural incompatibilities, and know how to build bridges or establish linkages across cultures that facilitate the instruction process. (Gay, 1993, p. 293)

7.1 Introduction

In this chapter, I explore the engagements of the science teachers during the intervention workshops by the Indigenous Knowledge Custodians (IKCs). The chapter presents, interprets and discusses data from the presentations by the three IKCs, namely, Umhlekazi, Majeke and MaMtshawe. Taking counsel from the above epigraph, one of the goals of this study was to support science teachers to become cultural knowledge brokers.

In the context of this study, cultural knowledge broker is a concept used to describe the science teachers from a township school who acted as intermediaries and negotiated between outwardly different cultures, languages and social and political systems (Wyatt et al., 2017). Moreover, this study involved using IK to teach science which resides in community members (Breidlid, 2013). It is for this reason that, in this study we invited the IKCs to present and demonstrate cultural practices related to the sea and to conduct practical demonstration lessons on how to make *isonka samanzi* (homemade bread) to the science teachers.

7.2 Intervention Workshops

The main aim of these workshops was to tap into the funds of knowledge and wisdom of IKCs.

7.2.1 Introduction

In this section, I present the data generated from the intervention workshops to answer research question 3:

What learning opportunities are created (or not) during the presentations by the IKCs?

The intervention workshops were conducted in response to the gaps that emerged in the baseline or mirror data gathered earlier on. It emerged from the baseline data that despite the curriculum expectations that teachers should integrate IK into their science lessons (DBE, 2011), they were not integrating IK, or they were not confident enough to integrate IK to make science relevant and accessible to learners. Thus, it emerged that there was a need to tap into the cultural heritage of IKCs (Klein, 2011; Lavallee, 2009; Mateus & Ngcoza, 2019), to assist the participating science teachers in becoming cultural knowledge brokers (Wyatt et al., 2017).

Traditionally, parents are usually invited to schools to be informed about the progress of their children or challenges such as ill-discipline, theft or fighting. Contrary to that tradition, what was done differently in this study was parents who were community members – herein referred to as IKCs – were invited to school to share their local knowledge or IK with the science teachers. That contributed to the uniqueness and significance of this study. In the following sections, I thus present, analyse and discuss data generated from tapping into the cultural heritage of community elders, namely, Umhlekazi (a pseudonym referring to a traditional healer or a Sangoma), Majeke and MaMtshawe (clan names).

7.2.2 Data from Umhlekazi

The next section reveals who Umhlekazi is, how I got to know him and the engagements that took place.

7.2.2.1 How I got to know Umhlekazi

After the 2020 Covid pandemic, Buyelembo experienced a different kind of pandemic. At the beginning of 2021, some learners displayed unfamiliar behaviour and sicknesses at Buyelembo Combined School where this study was conducted. I was called to a grade 11 class because a certain usually disciplined young boy Ohlaselweyo (pseudonym – meaning the attacked one) demonstrated violent behaviour, lifting desks and throwing things at everyone.

In another incident, a grade three learner – Umrhubuluzi (the crawling one) – a young girl crawled like a snake in class displaying unusual behaviour. When the teacher tried to talk to her, she was physically attacked by a child who had unnatural strength. Umrhubuluzi also attacked one of the mothers who work at the school as a food handler, assisting with the school nutrition programme. Again, I was called in as a school principal. As if my faith was tested, a grade 10 girl Othwasayo (Pseudonym meaning the one called by the ancestors) also had an

outburst in class claiming that she was seeing elderly people and hearing them telling her to leave school. When people tried to calm her down, she demonstrated violent behaviour and unusual strength. This behaviour disrupted teaching and learning.

Also, one morning, a grade 7 girl, Ochongiweyo (the chosen one), came to school wearing animal skins on her head claiming that she had been called by the ancestors to be *igqirha* (a traditional healer or a Sangoma). Her appearance caused some panic in her class and the teacher sent her to my office. After listening to her explanation, I called her parents. When the parents arrived, I asked them what was going on as they knew that wearing animal skins was not part of the school uniform. The parents indicated to me that a qualified healer they consulted gave her those things to wear for the child's protection. I requested the contact number of the Sangoma and called the Sangoma to enquire about the situation and his involvement. After I had introduced myself to him, he kindly offered to come to school and explain the situation. That is how I got to know Umhlekazi (that is what we call traditional healers in Xhosa).

Indeed, he came to school and explained that the animal skins were meant to protect the child from demonic attacks. I explained to him that the child's appearance caused some fear and panic at school. To resolve the situation, Umhlekazi, who was very cooperative, gave the child permission to wear a white or blue wool hat (which are the same colours as our school uniform) and we agreed to this compromise arrangement. The child's parents were also present in the meeting, and they agreed to the arrangement and the matter was resolved.

I thanked Umhlekazi for understanding and asked him if he would be open to the idea of coming to school and presenting to the teachers how to handle learners who claimed that they had been called by ancestors to become traditional healers. Umhlekazi agreed to come to school on a set day. I took advantage of this and explained to him that I was conducting a study, and I was interested in hearing his views about cultural practices and beliefs associated with the sea from the traditional healers' point of view. Fortunately for me, he agreed to present both items on the set day. Thus, the relevance of employing Ogunniyi's (2007) CAT, which can be applied to harmonise two distinctive worldviews - IK, religion and WS - in the context of this study.

7.2.2.2 Umhlekazi's cultural heritage

Traditionally, when someone wants to consult with a Sangoma, they have to visit the Sangoma's home (in isiXhosa we say *kuthathwa iintonga*). What was done differently in this study was to invite Umhlekazi to school to share his knowledge, wisdom and expertise with

the teachers to make us understand and capacitate us to be able to deal with the learners better at our school. This was done because a similar situation had occurred at another township school in the Eastern Cape, where a learner committed suicide and left a note that he felt like an outcast as he was criticised by the teachers because of his calling to be a Sangoma and the learners made fun of him and that pushed him to commit suicide. So, our interest was that we wanted to learn how to handle such situations and not to see a repeat of such an unfortunate incident. It must be noted that it was intended that Umhlekazi would present and practically demonstrate the cultural practices at the sea with a focus on waves and sound. My study was on Indigenous practices related to the sea and it was hoped that Umhlekazi would go to the sea with us and demonstrate practically. However, we could not go to the sea with Umhlekazi because he indicated his reasons and ethically, we had to respect that. Nonetheless, we felt that there was a lot to learn from him in terms of cultural practices related to the sea. Unfortunately, science falls short in terms of understanding and explaining spirituality and I understand that and that is why I used CAT in the study as it acknowledges spirituality. Figure 7.1 shows Umhlekazi presenting to our PLC.

Figure[10] 7.1: A picture of Umhlekazi presenting to our PLC

On arrival, I welcomed Umhlekazi to the school and thanked him for coming to our school. We did not shake hands out of respect because traditionally most Sangomas do not shake hands, and we observed that he had a phone in one hand and car keys in another hand. There is a cultural belief that traditional healers do not shake hands because they fear that *uzakumka*

10 Umhlekazi consented for his photograph to be used in this thesis and has requested its copy.

umhlola (meaning the Sangoma will lose the ability to reveal to you what you are consulting about). So, we assumed that Umhlekazi did not shake hands, and we did not shake hands. However, during our reflection and discussion, we realised that we had missed an opportunity to find out from Umhlekazi whether he shook hands or not. So, we agreed that I should call him and find out from him.

I called Umhlekazi who was very friendly on the phone and told me that he had saved my number. I was humbled to hear that. Then I told him the reason I called and asked if I could put him on speaker for the benefit of our PLC and he agreed. To our surprise, Umhlekazi told us that it is the essence of Ubuntu as Africans to shake hands and that he did not believe that it was good practice for Sangomas not to shake hands. He explained that he was aware that some Sangomas did not shake hands because they believed *uzakumka umhlola* and hastened to say *nothi kum* (that does not happen to me) and others did not shake hands because they did not want to detect something from you without proper consultation. He emphasised that one of the reasons for him to shake hands was so that he could get a revelation if someone needed his help. He asserted that he was called to help people, and I observed that he was very confident about his calling. I was reflexive throughout the study.

After the greetings, I again explained why we had invited him. I indicated that we would appreciate it if he could do his second presentation at the beach. Unfortunately, he refused to go to the sea out of respect for his ancestors and his calling (Chilisa 2012; Mertens, 2010). These scholars emphasise the importance of establishing a trusting relationship between the PLC and IKCs. He explained that he only went to the sea to perform rituals and hinted there could be consequences if we went to the sea, but he did not provide further explanation. We offered him some coffee or tea before we started our conversation, but he refused and thanked us for our kindness. I explained to Umhlekazi the different behaviours of some learners as indicated above. For instance, Ohlaselweyo (pseudonym – meaning the attacked one) demonstrated violent behaviour, lifting desks and throwing things at everyone and other unusual learner behaviours. I now present and analyse the data that emerged from Umhlekazi's presentation on how to handle learners at school who claim that they have been called by ancestors to be traditional healers. Below is a summary of what Umhlekazi told us:

> *Okokuqala mandibulele lembeko ingaka ndiyiphiwe sisikolo. Ayivamanga Sihlwele ukuba sibizwe ezikolweni sizinyangi, mna ndiyaqala ngqa ukulibeka olwam unyawo esikolweni ndizokubonisana notitshala ngendlela yokuphila nabantwana abathwasayo. Ngaske izikolo zenjenje, kuba ngokwenene ingxaki zizakubakho ukuba otitshala abakhanyiselwanga* (Firstly, let

me thank the school for this honour. It is not usual that healers are invited to schools; it is my first time to be invited to a school to explain how to deal with learners who are called by the ancestors. I wish all schools would follow suit, because if they do not the challenge will continue because teachers are not clear).

Then, Umhlekazi said:

Okokuqala mandicacise indidi zemimoya, kukho ukubizwa ngabantu abadala, ***abathwasi****, kukho* ***amakhosi****, ukanti kukho* ***namafufunyana****. Lamfundi wokuqala Ohlaselweyo unamakhosi, uwafakwe ngamagqirha khonukuze abenamandla sihlwele, lowesibini Umrhubuluzi yena kuyacaca ukuba unefufunyane, amafufunyana afakwa ngamagqwirha lento kuthiwa umntu ubulewe, aba babini bokugqibela Othwasayo no Ochongiweyo bona bayathwasa, bagula ngengulo emhlophe, abantu bakokwabo bafuna ukubasebenzisa*.(Firstly, let me explain about the different types of spirits; there is a calling by ancestors (Othwasayo and Ochongiweyo); there are spirits that are put inside the person by traditional healers to make them strong (Ohlaselweyo), and there are demonic spirits that are sent by witches or wizards to make a person sick and ultimately kill them (Umrhubuluzi)).

He further explained that a powerful Sangoma can help get rid of those spirits in Ohlaselweyo and Umrhubuluzi or they can be taken to a pastor who specialises in healing ministry to help them. He continued:

Xa umntwana ebizwa ngabadala uba nezimbo, omnye ufika alale esikolweni, omnye atyhafe, omnye aphendule krwada kuxhomekeka kwesisihlwele athwasela sona. Akaziva sihlwele, akenzi ngabomi wenziwa yingulo (When a child is called by the ancestors they demonstrate certain characteristics, for example, they sleep in class, they get tired all the time, some become rude to teacher; they depend on the ancestor that have called them; they don't do it deliberately).

He explained further:

Xa enjalo ndicebisa otitshala babize abazali bakhe basabele, ukuba sikhona isidingo kubiswe umntu omnyangayo. Okwesibini, xa evukwe ngumoya, kufuneka anikwe amanzi asele. Ukuba undlongondlongo makathothomaliswe ngesiduko sakhe, kuba kuthethwa nesinyanya akusathethwa naye kuba kwantu wakubizwa nesiduko umele uhle kuba ubizwa ngabantu bakowenu, okokugqibela Shlwele ukuba akade alunge kuzakunyanzeleka anqunyanyiswe esikolweni ayokunyangwa agqitywe, isikolo yindawo yokufunda nothi eyokuthwasa ngokoke abazali mabathathe uxanduva ngabantwana babo baqinisekise ukuba bonke abantwana bakhuselekile esikolweni, andazi nokuba niphendulekile? (When a child demonstrates these symptoms, the school must call his or her parents to hear what could be the problem. If there is a need the healer who is in charge of the child must be consulted. Secondly, when the spirit takes over, you must give the child water to drink; that will calm them down, but if they demonstrate violent behaviour or act in an ill-disciplined manner, you must address the child by his or her clan name and by so doing you are addressing his ancestors. If all this fails, then the school must ask the parents to take him/her to the healer and they should only be allowed to come back when they are completely healed. I don't know if I have answered your question to your satisfaction?).

Four things emerged from this presentation:

- Parents must be called for an explanation of what could be the problem.
- If there is a need for more information a traditional healer in charge of the child must be called to assist.
- When you observe any of these symptoms the child must be offered water to drink, because water has a calming effect when it comes to spirits.
- If the child demonstrates signs of being rude, address them by their clan name; in this way you are addressing his ancestor.
- If all fails, the parents must agree to take the child to a traditional healer and not allow the child to come to school until completely healed.

Finally, he indicated that the school was a place of learning so parents should take full responsibility for the protection of other learners. In this regard, Msomi and Ahurst (2023) maintain that power lies with the community and relevant stakeholders to propel our township school into the envisaged transformed schools. However, Aikenhead (2006) and Ogunniyi (2007a) proffered that schools viewed community members as ignorant and were not given an opportunity to share IK with schools since such knowledge was considered irrelevant. Yet, based on the lessons learned by the teachers from Umhlekazi, a call should be made that IKC must be invited to schools because they are indeed the custodians of IK (Smith, 2012). In the above epigraph, Gay (1993) reminds us about the role of cultural brokers.

Thus, data revealed that this study opened up an opportunity for the participating science teachers to be cultural brokers, as they were empowered by Umhlekazi in two ways as revealed above. Firstly, to be able to distinguish what type of a spirit has possessed the learner and what kind of help they needed. Secondly, how to handle *abathwasi* at school without denying them the right to learn. After this informative presentation, I asked Umhlekazi to address the second part of the question which sought to understand what cultural practices and beliefs were associated with the sea.

In his response, Umhlekazi said: *"Kukho ukuhlwayela, kukho ukuthwethyulwa, nokudlokova kolwandle"*. He mentioned three things, but I found these to be difficult to translate into English, and perhaps the reader will get the meaning of each from the explanation he provided. Umhlekazi said:

> *Ukuhlwayela kwenziwa elwandle xa kuphethwe umsebenzi wekhaya, mhlawumbi kusetyenzwa umntwana welokhaya. Lomsebenzi ukhokelwa ligqirha, kuphathwe intlobo ngentlobo zembewu (eyethanga, umbona, ingqolowa njalonjalo) kuphathwe necuba neentsimbi. Zonke ezo zinto zikhutshwa njengezipho kubantu abadala, zibekwe esityeni phezukolwandle, zizakuhamba zide ziyokutshona ndaweni ithile, ukuba icamagu livumile, isitya sibuya sinezipho ezivela kubantu abadala ezinjenge mbewu neengcambu zamayeza, nibone nemiqondiso, umzekelo ningabona iintaka zindanda, okanye amaza azolileyo, okanye izilwana zaselwandle njalonjalo, lomsebenzi wenziwa okugxotha indlala neshwangushe nokupha abantu abadala* (When a family performs a ritual of thanksgiving, they place various kinds of seeds such as pumpkin seeds, mealies, tobacco and beads on a metal plate and place it on water in the sea. The plate will move and not sink until it reaches a certain place where it will sink and come back with different kinds of seeds and plant roots to make medicine, and you will observe certain creatures like birds and sea creatures showing up. You will also observe calm waves. If that happens then you must know that the ritual has been successful. This kind of ritual is done to chase away bad luck and to give thanks to the ancestors).

I observed that the teachers were listening attentively. Zizi asked: *"What about gravity; will the plate not sink immediately?"* I could see from his facial expression that he seemed not convinced. Umhlekazi responded and said: *"I am telling you what I have seen happening several times, I don't know about gravity but what I know is that if the ritual has been successful that's what is going to happen".* It is probably experiences like these that led O'Murchu (2012. p. 6) to the conclusion that "Everyone seeks to interpret and understand their experience; unfortunately, our Western education, with its strong emphasis on rationality, has poorly equipped us for this understanding". Thus, scholars such as Klein (2011), Mutanho (2021) and Seehawer (2021) call for alternative approaches to make science accessible and relevant to the learners. Unfortunately, we did not engage Umhlekazi further on this subject, perhaps because of our Western educational training which is biased towards WS. I must admit this was a missed opportunity in this study. However, since we used an LS approach in this study, I believe we can still engage Umhlekazi on this matter for further clarification at a later stage to broaden our understanding. In LS, you always reflect after each lesson and look for areas for improvement; that is how you develop and improve your teaching practice.

Hatcher et al. (2009, p. 142) proffered that "Western Science involves a disconnection between the observer and the observation". Likewise, Ritske (2011) asserts that Indigenous spirituality acknowledges the value of connection to all aspects of the self, connection to the environment, connection to history and connection to a higher power. The tension between IK and WS was evident in this question and response. Proponents of IK advise that any misconceptions embedded in IK and cultural beliefs should be discussed and clarified (Afonso-Nhelevilo, 2013; Keane et al., 2016; Mhakure & Otulaja, 2017; Mukwambo et al., 2014; Ogunniyi,

2007a). Like these scholars, my personal experience (see Section 1.3) has led me to trust the foundational wisdom of IKC while acknowledging that like all human perceptions, such wisdom can sometimes be inaccurate or misplaced, though they must be acknowledged and clarified. However, I was impressed to see Umhlekazi standing his ground against Zizi's Eurocentric notion and even more impressed to hear him respond in English so fluently, it revealed the power of translanguaging and the ability to engage meaningfully with almost everyone (Mapfumo, 2024).

Referring to the ontological difference between IK and WS, MaMyeka wrote in her journal:

> *The tension between the teachers and the traditional healer was rather tense. The reason maybe that people do not want their secrets to be told in front of others. It was hard to maintain eye contact with him as some of the things he said personally touched me.*

MaMyeka later explained to me that some of the things the Sangoma mentioned spoke to her family ritual ceremonies that they still had to carry out, but they had put them on hold because of financial constraints. She further explained: *"You have to be an African to believe this as it cannot be scientifically proven; blacks have their own science that has kept them going for years"*. In this situation, Ogunniyi's (2007a) CAT was used as a lens and helped me to harmonise the engagements and arguments of the two distinct worldviews, the WS held by Zizi (*dominant)* and IK held by Umhlekazi (*emergent)*. It could be argued that MaMyeka's statement was *equipollent*. The study provided the teachers with an opportunity to engage and argue and not take things at face value.

A similar trend was observed throughout the presentation by Umhlekazi. For instance, when he explained that there were houses in the sea where ancestors lived and explained that *ukuthwetyulwa was* a term given when an ancestor took someone into the sea and that person would come back as a qualified Sangoma if his family did not cry. I observed that it was difficult for most teachers to comprehend some of the IK shared by Umhlekazi. For example, MaMpehle asked: *"How do they breathe under water and what do they eat?"* To this, Umhlekazi responded and said: *"There is another world out there with different rules to this world"*. This resonates with the two-eyed-seeing scholars such as Hatcher et al., (2009) and Onwu and Mufundirwa (2020) who emphasise the concept of multiple realities embedded in IK, and that reality perceived by our five senses is but one of those. I have come to understand that engaging our complex world in a meaningful way requires familiarity not just with one

dominant WS worldview but with several related disciplines such as IK (Bhagwan & Chan, 2014; Michie et al., 2021; O'Murchu, 2012).

Thereafter, Umhlekazi explained the tides and the debris that come out of the sea as a sign of whether the ancestors were happy or not (*ukudlokova kolwandle*). However, he indicated that high tides occurred during the full moon and the ancestors demonstrated their anger resulting in Tsunamis. He further explained that slaughtering an animal at the sea to perform rituals was forbidden by the ancestors and the killing of certain sea creatures resulted in these Tsunamis.

MaNgconde responded and said in science we refer to this as constructive and destructive interference of pulses. To me, her responses suggested that science teachers could use myths to explain scientific concepts and clarify any confusion that the learners brought to class. As alluded to earlier, Seehawer and Breidlid (2021) proffer that in this third space, there is a dialogue between IK and WS. Thus, an opportunity for learning was created during the presentation by Umhlekazi which provided an opportunity for CPD (Ngcoza & Southwood, 2019) and a shift of PCK in terms of the integration of IK. Mazzocchi et al. (2018, p. 21) argued that "by isolating and decontextualising bits of information from the overall sociocultural setting, which can be seen as a form of (methodological) reductionism, the full significance of Indigenous practices cannot be grasped". In that regard, the study sought to bring to the table what transpired during the research process.

Next, I present and discuss data gathered from two other IKCs who participated in this study.

7.2.3 Data from Majeke and MaMtshawe

In this section, I present and discuss the data generated when Majeke and MaMtshawe did their presentations to our PLC. One afternoon our PLC, Majeke and MaMtshawe went to the sea as part of the research process. The reason for going to the sea was that we wanted to use the sea as an out-of-school context as mentioned by Agunbiade (2015) and Graven (2012). Before the start of the presentation, I followed the Ubuntu perspective and thanked Majeke for honouring us with his presence and for his willingness to share his cultural heritage with us. After that, I introduced Majeke as follows: *"Elixhego ngu Mnkabane, Nokwindla, uNoqaza, uMthiwembhotyi, inkwalizipinki nokubazinentsente"*. Basically, I quoted his generations according to his clan name; this is how we introduce each other in an African culture. We shook hands as per the tradition.

Figure[11] 7.2: Showing Majeke and MaMtshawe co-presenting to our PLC at the sea

Thereafter, I handed over to Majeke to start his presentation. Majeke greeted everyone and said he appreciated the opportunity given in a typical Xhosa way saying: *"Ndiyabulela Cirha noTitshala, andiyithathi kancinci lenyhweba nindiphe yona, ndiyathemba uThixo uzakusinceda, ubalulekile mkhulu umsebenzi eniwenzayo ningoTitshala"* (I thank you Circa and the teachers. I do not take it lightly; this is an honour and a privilege for me, and I trust that God is going to help us. You are doing an important job as a teacher).

After this heart-warming compliment from an elder (which is something big in the African culture), Majeke took us through cultural practices and beliefs associated with the sea and rivers in isiXhosa as the MKO. According to Vygotsky (1978), language (isiXhosa in this context) is considered a most crucial mediation cultural tool during social interactions; the use of isiXhosa allows science teachers to learn (Lemke, 1990). During my master's research, Majeke was one of the participants and he spoke to my grade 10 learners who are in grade 12 this year. This time around he gave more detail and explanation as he engaged with the teachers. His approach was different this time around as he mainly used *storytelling* as a teaching tool (Nhase & Dube, 2023; Mucina, 2011). This resonates with Iseke (2013) who argues that *storytelling* is a central focus of Indigenous epistemologies, pedagogies and research approaches. In a similar vein, Smith (2012) and Seehawer (2018) aver that *storytelling* reflects the orality of many African cultures and is a way of transmitting knowledge.

[11]All the participants consented for their photographs to be used in the thesis and requested copies of the thesis.

Something interesting happened as Majeke was presenting MaMtshawe interrupted, either agreeing with Majeke or adding to what was being said. Majeke seemed comfortable with this; for instance, Majeke repeatedly said: *"Andithi MaMtshawe?"* (Don't you agree MaMtshawe?). In the Xhosa culture, this statement is seen as a polite invitation to contribute to a discussion. In other words, Majeke encouraged MaMtshawe to contribute and as a result, they ended up co-presenting as shown in Figure 7.2 above. He was giving women *a voice*, the ones who have been marginalised the most. Even though I did not approach MaMtshawe to be a participant in the study, it would have been rude in Xhosa culture to tell her that she was not a participant in the study. The Ubuntu perspective did not allow me to ask her to complete a written consent form before participating. By contrast, in terms of Ubuntu, she showed kindness, and her actions should be viewed as being generous and ought to be appreciated. Indeed, MaMtshawe's participation contributed to the uniqueness of this study as she reminded Majeke of some things and validated his input. As mentioned earlier, Majeke's presentation helped us to answer the research question: *What learning opportunities are co-created (or not) during the presentations by the IKCs?*

I observed that both Majeke and MaMtshawe were knowledgeable about the sea and cultural practices and beliefs. For instance, they stated that several attempts had been made to build a harbour at that sea, but they had all failed as the construction had been demolished at night by an unknown force. To these IKCs, the unknown force was the ancestors who were unhappy about the building of the harbour in that spot because it was their home. They supported their claim indicating that several shipwrecks took place at that very spot. For example, Majeke said: "*Elilwandle, kanye lendawo inembali nodumo lokuntlitheka kweenqanawe nokuduka kwabantu abaninzi*" (This spot in the sea has a history of shipwreck and the disappearance of many people). The Tourism Office of Ndlambe Municipality confirmed that there were attempts to build a harbour, but they all failed and the project was terminated. They say nobody provided any scientific explanation about the failed attempts. Admittedly, spiritual things are difficult to explain scientifically, and learners come to the classrooms with this knowledge. Should science teachers dismiss it or embrace it? This points to the fact that just like any knowledge, WS has its own limitations, and perhaps the time has come for educationists to find a way of integrating IK and WS (Mazzocchi et al., 2008).

These IKCs also concurred with Umhlekazi's assertion when he spoke to us earlier on indicating that certain rules had to be followed when visiting the sea or the river to do rituals. For instance, they mentioned the following cultural beliefs:

- A twin had to throw in coins or part of their hair before stepping into the water.
- There are people who have been called into the sea and come back as Sangomas (*Abathwetyulwa*) or come back dead with eyeballs taken out and painted with a white paint that Sangomas wear depending on the response of the families of those people that have been taken into the sea by the Sangomas.
- They indicated that professional life savers and divers have been called to search for *Abathwetyulwa* but their attempts have been unsuccessful in trying to find them and bring them back.
- They have witnessed *umhlwayelo* (presentation of gifts to the ancestors in the form of bids, seeds and *umqombothi* (African beer). All of these items were placed in a container and floated into the sea, and the container would come back with different kinds of seeds as a sign that the gift was accepted).
- There is another life inside the sea (referring to ancestors or spirituality).
- They emphasised the importance of singing traditional songs and beating drums as part of communication with the ancestors when doing the ritual at the sea or the river (*Kubalulekile ukucula iingoma zakwantu nokubetha amagubu xa nisebenza umsebenzi wolwandle okanye umlambo ngoba yindlela yokuthetha nabantu abadala*).

The IKCs shared knowledge that had been acquired and transmitted orally from generation to generation (Kibirige & Van Rooyen, 2006; Seehawer, 2018). Majeke explained the concept of low and high tides as follows:

> *Kuyaxhomekekeka ukuba inyanga ijongene njani nolwandle, umzekelo xa inyanga iliceba okanye ibukekela ulwandle luyehla, lulushiye unxweme olu sikulo kungabikhomanzi, ukanti xa inyanga igcwele ibusondela phezukolwandle, ulwandle luyaphakama amaza ebe bungxama ukuza nganeno, lendawo sikuyo izale ngamanzi* (It depends on the moon; for example low tide is formed when we have a quarter moon or when the moon is at an angle, then the sea goes back leaving this section dry, but when there is a full moon and when that gets closer to the sea, the sea rises and sends waves forward until the water gets to this point).

Majeke might not understand the mathematical development of tide-generating forces or the physics of gravitational interactions between the sun, moon and the earth as Hicks (2006) does, or he might not know green and golden seaweed tides that Smetacek et al. (2013) talk about

but for someone who has little formal education, he seemed to have a sound understanding of how tides are formed. Unfortunately, according to O'Murchu (2012 the WS tends to underestimate and misjudge the richness embedded in Indigenous experience. It seemed that his explanation of tides had a profound impression on the teachers. I could tell from their facial expressions that they were amazed. He continued to explain and said:

> *Ngamanye amaxesha xa izinyanya ziqumbile, sele kungekho nyanga ulwandle luyaphakama luze ngamandla, xa lisihla libuya umva xa kusenziwa umsebenzi lonto ibonakalisa ukuba namkelekile* (When the ancestors are angry with you, the sea rises and sends forth high waves, but when you do a ritual, if the sea becomes flat and moves backwards, that is a sign that you are welcome to continue with the ritual).

I noticed that the teachers seemed very interested in Majeke's explanation. However, I could not tell whether they agreed with him or not. The teachers' roles were to engage with the IKCs and identify scientific concepts or explanations or myths related to the topic of waves and sound and write down the lessons they have learned during the presentation. For instance, Madiba said:

> *There is no question in my mind that Majeke and MaMtshawe are knowledgeable about the sea more than most of us science teachers. The fact that whites tried to build a harbour and failed because the ancestors refused is evidence that we cannot deny that spirituality plays a role in the sea … I was more impressed with his understanding of how tides are formed, the link between the moon and the sea, I can say Black people know science and Indigenous knowledge must be part of the curriculum our learners will learn so much.*

In his undergraduate degree, Madiba majored in physics and this excerpt seems to suggest that he was happy about the presentation and has learned something from it and joined the call that IK should be integrated into science lessons. However, it must be noted that not all cultural beliefs and practices are relevant to science (Mayana, 2020). As alluded to earlier (see Section 2.8), even scholars who are proponents of IK caution against the romanticising of IK (Afonso-Nhelevilo, 2013; Keane et al., 2016; Mhakure & Otulaja, 2017; Mukwambo et al., 2014; Ogunniyi, 2007a). These scholars advise that any misconceptions embedded in IK and cultural beliefs should be identified and corrected. On the other hand, MaMpehle who is a Foundation Phase teacher and who did not do science at the university level, had this to say about the presentation:

> *Mna andiyazi iscience nembali yezibuko lalisakhiwa izinyanya azavuma, kodwa namhlanje ndifunde isinto ezininzi. Ndifunde nge tides, ngezinyanya bendingayazi ukuba uMaMtshawe wazi kangaka naye mna ndibona umama nje hayi ndiyamhlonipha* (I don't know much about science

> and the history of the harbour they attempted to build but the ancestors refused it. I learned about the tides, the ancestors' involvement. I also did not know that MaMtshawe was so knowledgeable; to me she was just an ordinary mother. From today I respect her).

From this excerpt, it seems MaMpehle learned about the history of the Port Alfred beach, the involvement of ancestors and the formation of tides. Most importantly, she learned not to take people for granted as she confessed that she did not realise that MaMtshawe who is a school clerk was so knowledgeable. This is new knowledge in this study. Meanwhile, Zizi indicated that: *"Sithi iSiXhosa inyathi ibuzwa kwabaphambili, umzali uye wandixelela izinto bendikade ndiziva ngingakholelwa, kodwa ngenxa yemfundiso yakhe ndiyazikholelwa, siyabadinga abazali kwimfundo)"* (The elder took us through the matters of the ocean and ancestor. It is true that we indeed need parents in education).

Zizi concluded that teachers should enquire from the elders, *omakadebebona,* and indicated that we need parents in education when he said *"Inyathi ibuzwa kwabaphambile, siyabadinga abazali kwimfundo"*. Several scholars such as Klein (2011) and Mateus and Ngcoza (2019) emphasise the importance of tapping into the cultural heritage of community members. It seems that Zizi learned from *omakadebebona* the knowledgeable others (Vygotsky). I observed that this seemed to be a general trend, for instance, MaMhegeba said:

> *It was an eye-opening and informative session; I have learned that Indigenous knowledge cannot be separated from our curriculum because there is a strong connection between nature and the ancestors … today I have learned that there is a strong connection between the moon and the sea through tidal waves.*

MaMhegeba's comment that IK cannot be separated from the curriculum seems to be in line with the view that learners' sociocultural experiences at home are the foundation for their future learning (Chikamori et al., 2019; Dahal, 2018; Mavuru & Ramnarain, 2020). Concurring with this view, MaMyeka said:

> *I have observed that Majeke is highly knowledgeable man, his understanding of tides, the moon playing a great part in wind speed and tides is so amazing. I did not know that the moon had anything to do with tides in the sea, he opened my eyes, I have learned a lot we need IK in our lessons.*

Similarly, MaNgconde said:

> *The science of ibhekile yomqombothi that won't sink until it reaches a certain point in the sea (defying the laws of gravity) is something that I used to hear in the streets. Beside the knowledge*

of science from Majeke, it was interesting to learn everything outside the classroom. I learned so much from the presentation things I used to ignore.

These teachers' reflections reveal that multiple learning opportunities were created during the presentation by the IKCs. Most importantly, the teachers seemed to agree that the integration of IK into science lessons was a necessity. At the end of the presentation, Zizi thanked the IKCs on our behalf and indicated that we had learned a lot from them to the approval of everyone as they said: *"Sifundile kakhulu siyabulela kakhulu"* (We have learned so much, thank you very much) which is a typical African response when people are happy about something. Majeke had the final word as an elder and said: *"Kubulela mna nangona ndingafundanga ndiyayithanda kakhulu imfundo"* (I thank you all; even though I am uneducated, I love education). Thereafter, we said our goodbyes and went home. The next day we had our reflections session where it emerged from that we had all found the co-presentation to be effective and we agreed that we should try co-presenting some topics especially the challenging topics as a teaching strategy to mediate learning. I observed that everyone was looking forward to the next presentations on kitchen chemistry.

7.3 Chapter Summary

This chapter presented the data generated from the workshops and analysed the learning opportunities presented in them. The data revealed that learning opportunities were created by the study because teachers were able to generate new ideas on how to tap into community members' IK, and how to draw links between IK and science. Evidence of transformation could be seen in the teachers' ability to draw links between IK and science, which they had battled to do before the intervention. Based on my observation of how the science teachers interacted with the IKCs during their presentations, it seemed that the teachers learned several things. For instance, they learned about the different kinds of spirits and how to handle children who are possessed by these spirits, what Gay (1993) referred to as interpreting symbols from one frame of reference to another. Also, the teachers learned that dealing with IK implies dealing with different ways of understanding reality because each ethnic group (such as Africans and Europeans) has its own worldview (Mazzocchi et al., 2008). Thus, one could argue that they became cultural brokers (Gay, 1993). Furthermore, they are now able to do document analysis and co-develop their own lessons that integrate IK. The study concludes that the science teachers' ZPD and PCK were affected positively.

CHAPTER EIGHT: KITCHEN CHEMISTRY

> If practical activities are planned and well organised, the outcomes can be very rewarding in terms of meaningful learning. (Woodley, 2009, p. 50)

8.1 Introduction

In this chapter, I present the data generated from the two practical demonstrations of kitchen chemistry. The first practical demonstration was conducted by MaMcirha, an IKC who demonstrated how to make *isonka samanzi* (homemade bread). The second hands-on practical activities were conducted by Nozinga a critical friend from Rhodes University who demonstrated how to do hands-on practical activities using easily accessible resources (Asheela et al., 2021). I thus present the data generated from each practical demonstration lesson herein referred to as kitchen chemistry[12], and analysed the learning opportunity provided.

8.2 Tapping into MaMcirha Funds of Knowledge and Cultural Heritage

It is acknowledged that this study explored how to decolonise the curriculum in school science by inviting IKCs to conduct practical demonstration lessons on how to make isonka samanzi (homemade bread) for the science teachers at Buyelembo Combined School in South Africa. For that reason, there was a need to explore the literature on hands-on practical activities and inquiry-based learning (IBL) in school science. According to Shinana et al. (2021), IBL is learning that involves practical hands-on activities where learners investigate scientific phenomena through engaging in hands-on practical activities.

The data gathered from MaMcirha's practical demonstration helped me to answer the following research questions 3 and 4:

[12] Kitchen chemistry refers to the chemistry of everyday activities performed in households, such as cooking and cleaning (NISE, 2020).

- What learning opportunities are created (or not) during the presentations by the Indigenous Knowledge Custodians?
- What learning opportunities are co-created (or not) during hands-on practical activities on kitchen chemistry?

Notably, Indigenous practices can be in the form of hands-on practical activities enabling the visualisation of science concepts (Nikodemus, 2017; Shinana, 2019). In this study, MaMcirha, affectionately known as Cirhakazi demonstrated that this statement is true when she showed our PLC how to make *isonka samanzi* (homemade bread) (Nandjedi, 2022) at Buyelembo Combined School where the study was conducted. MaMyeka, one of the participants in this study, volunteered to facilitate the workshop and introduced Cirhakazi:

> *Siyakwamkela Cirhakazi, kudala siyilangazelela lemini, siyakholwa ukuba ulwazi ozakusabela lona luzakusinceda sivale umsantsa phakathi kwezululwazi nencubeko yakwantu, sinqwenela ukufunda kuwe, ngalomazwi wamkelekile zive usekhaya Cirhakazi* (We welcome you Cirhakazi, we have been looking forward to your presentation, we believe that the knowledge and experience that you will share with us is going to help us in bridging the gap between Indigenous knowledge (IK) and Western Science (WS), so with those few words I welcome you all, feel at home Cirhakazi).

MaMcirha wasted no time and she in turn thanked MaMyeka for a warm welcome (*Enkosi mam ngendlela ondamkele ngayo ndiziva ndamkelekile*). I noticed that MaMcirha had a warm smile and seemed happy and ready for her presentation. Also, her respect for MaMyeka was so humbling as she addressed her as 'ma'am'. MaMcirha presented in isiXhosa, her mother tongue, and explained each step as she practically demonstrated how *isonka samanzi* was made using Indigenous methods. The teachers also addressed Cirhakazi in isiXhosa confirming that there is a close link between speaking and learning (Sedlacek & Sedova, 2017). She started her presentation and said:

> *Sizakuqalisa ngoku ukwenza isonka samanzi, izinto esizakuzisebenzisa zezi, i5kg yomgubo, emva koko ndizakugalela igwele, igwele ndiligalelela ukunyusa intlama. Ungasebenzisa igwele elinye xa usebenzisa u5kg womgubo, okanye amagwele amabini xa usebenzisa u10 kg womgubo. Emva koko sigalele intwana yeswekile nentwana nethyuwa zona zezokuncasanisa. Wakugqiba ukugalela ezizinto uyazidibanisa zisomile zinjalo, emva koko ugalele amamzi adikidiki kulomxube wakho, ugalela amanzi adikidiki kuba amanzi abilileyo okanye ashushu kakhulu azakulitshisa igwele lingakwazi ukunyusa intlama. Kubalulekile ukuba uyixove intlama uqinisekise ukuba idibene, uyaqinisekisa ukuxova umane ugalela umgubo owomileyo de isuke esandleni kungashiyekintlama kuwe. Emva koko intlama siyifaka esityeni esikhulu siyigqume imizuzu engamashumi amathathu, siqinisekise ukuba ifudumele ngokwaneleyo khonukuse intlama izokwazi ukugcina ubushushu izokwazi ukunyuka ngoba xa igodola ayinyuki. Xa inyukile,*

siyayithatha siyifake kwisitya sencence esiqatywe ioli, sisifake embizeni enamanzi abilayo singawucimi umlilo side sivuthwe, enva koko singatyiwa (We are going to make steamed bread, the ingredients that we are going to use are flour, sugar, dry yeast, and salt. We first add the flour which is our main ingredient, we are using a 5kg of flour, next, we are going to add our dry yeast, dry yeast is used to rise the dough. You can use one packet of dry yeast when you use 5kg of flour, 10kg of flour will require two packets of dry yeast. Then we will use sugar, sugar is used for the dough/bread to have subtle taste. Next, we add salt, salt is also used for the subtle taste. Now we[13] will mix all the dry ingredients together. After we have mixed everything together we will take lukewarm water and add to the dry ingredients. It is very important to knead your dough well so that your ingredients will mix very well so that it can rise. After we have kneaded our dough we place it in a clean bowl and continue to knead it until your hand is no longer sticking to the dough. The next step will be to leave it for 30 minutes for it to rise. After your dough has risen, we will boil water and put our dough into an enamel bowl massaged with little oil and place it in the boiling water for 30-45 minutes, then it will be done then you will get your steam bread).

Figure 8.1 below show MaMcirha demonstrating her fund of knowledge to our PLC at Buyelembo Combined School.

Figure[14] 8.1: MaMcirha demonstrating how to make a dough (*intlama*)

MaMcirha was presenting and demonstrating practically at the same time. This resonates with Asheela et al. (2021) who argue that minds-on, hands-on and words-on approaches enable understanding of scientific concepts. I observed that she was not intimidated by the teachers; the smile on her face and the way she probed teachers to interact with her were unbelievable. For instance, she asked: *"Niyayazi kutheni sisebenzisa amanzi adikidiki singasebenzisi*

[13] Consistent with the indigenous research paradigm uMaMcirha uses 'we' instead of 'I' to emphasise the collectiveness of the indigenous peoples (Smith, 1999).
[14] MaMcirha consented for her photograph to be used in the thesis and requested its copy to show her children and grandchildren.

ashushu okanye abililеyo?" (Do you know why we are using lukewarm water instead of hot or boiling water?). This contradicts Taylor and Cameron's (2016) belief that Indigenous peoples have the know 'what' and the know 'how' but do not have the know 'why'. After a moment of silence, which to me was an indication that the teachers were not sure, she explained: *"Kungokuba amanzi ashushu azakulishisa igwele lingakwazi ukunyusa intlama"* (It is because hot or boiling water is going to burn the yeast and make it ineffective, and the dough will not rise). That is, enzymes are denatured by hot water (Nyamakuti, 2020; Shinana, 2019).

She continued throughout her presentation asking these probing questions to elicit our prior everyday knowledge (Kuhlane, 2011). For example, she asked: *"Kuzakwenzeka ntoni xa singayifudumalisanga intlama?"* (What will happen to the dough if we do not cover it and keep it warm?) Again, she answered her question and said: *"Ayizokunyuka iyagodola kaloku"* (It will not rise because it is cold, it needs warmth to rise). MaNgconde commented and said: "*Okay njengaphaya kwi rates of reactions?*" (Okay, similar to rates of chemical reactions). Lending support, Madiba added: "*We can use this to teach exothermic and endothermic reactions*". MaMhegeba indicated that: *"Kwa grade 7 singayisebenzisa ukutitsha imixtures sicacise homogenous ne heterogenous mixture"* (In grade 7 we could use this presentation to explain mixtures, the difference between homogenous and heterogenous mixtures). This resonates with Vygotsky's (1978) SCT, central to which is learning in a social context.

Figure 8.2: MaMcirha demonstrating how to cook homemade bread (isonka samanzi)

During the cooking process, MaMcirha explained: *"Ukuba amanzi aphele isonka singekavuthwa, ungaze ugalele amanzi abandayo, galela amanzi abililеyo"* (If the water runs

out before the bread is properly cooked, never add cold water, add boiling water instead). The teachers then asked why they must not add cold water but boiling water. MaMcirha explained and said: *"Kaloku sizakunyela, sibemanzi ngoba usibuyisela umva, xa ugalele amanzi abilileyo uyasithuma sivuthwe kakuhle"* (Because if you add cold water that would delay the cooking of the bread and the final product would be damp).

Madiba exclaimed and said: *"Le Chatelier's Principle, yes I have found a simple way to explain the effects of changes at equilibrium"*. Le Chatelier's Principle states that if a dynamic equilibrium is disturbed by changing the conditions, the position of equilibrium shifts to counteract the change to reestablish an equilibrium. I observed that the level of engagement and argumentation was very high with different science concepts emerging throughout the social interactions (Vygotsky, 1978) which was an indication that teachers were learning from Cirhakazi. For instance, an analysis of the teachers' reflections showed that four themes emerged. I now present and analyse each of the four themes (see Appendix N).

8.2.1 The teachers found the presentation to be interesting, clear and informative

The science teachers participating in this study stated that the presentation and demonstration captured their interest, and it was clear and informative. This resonates with Erinosho (2013), who indicates that hands-on practical activities are an enjoyable exercise that promotes motivation. This theme is supported by the following excerpts.

MaMhegeba said: "*This was an eye-catching, interesting, practical and clear presentation".* In the same vein, MaMpehle indicated: *"The session was very interesting, I learned a lot, for example, I learned that I had to use lukewarm water, but I did not know the reason for that".* Concurring with other teachers' views about the presentation Madiba highlighted that *"I found the presentation very interesting, clear and informative".* Continuing the trend, MaNgconde reflected that "the presentation of making dough by MaMcirha was very interesting".

I observed that these teachers seemed happy as their faces were painted with smiles. Research shows that hands-on, minds-on activities motivate learners and improve learning (Kuhlane, 2011; Shinana et al., 2021). The following excerpts took this further and added more insight:

> *Someone who has little education, a cleaner at school but possesses great and detailed knowledge passed on to her by her mother, the power of Indigenous knowledge. She is passing that knowledge on to her daughters.* (MaMyeka)

> *I had an opportunity to be part of the presentation done by MaMcirha. All I can say is that the amount of knowledge that MaMcirha has is so amazing, and her confidence to present to the teachers is unbelievable, she did a great presentation*. (Zizi)

Even though these teachers used different words, their responses highlighted the view that the integration of IK in hands-on, minds-on practical activities make learning interesting, motivates learners and makes the learning experience more meaningful (Shinana et al., 2021). These reflections shed light on the fact that the science teachers seem to have benefitted from MaMcirha's demonstrations as they found the presentation interesting and informative. This resonates with Feiman-Nemser's (2001) view that well-designed PLC programmes advance the teachers' SMK and help polish their teaching strategies.

8.2.2 Allowed the science teachers to see the practical link between IK and WS

The purpose of this study was to leverage the use of the Lesson Study approach when working *with* science teachers on how to integrate IK to mediate learning of the topics on waves and sound and redox reactions in a township school. Data revealed that MaMcirha's presentation assisted in the realisation of this goal. For instance, MaNgconde said: *"The presentation was very interesting such that it gave me more ideas to teach the rates of chemical reactions in my science class using IK"*. Concurring, MaMhegeba indicated: *"The presentation showed a clear link between IK and science"* and Madiba stated: "*The amount of IK that was used to explain difficult science concepts was just great and the way why we use this and that*".

These comments seem to be in line with the post-apartheid and Bantu Education transformation agenda of making science relevant and accessible to township learners in particular in South Africa (DBE, 2011). The study shows that the understanding of a link between IK and WS by the teachers was a learning opportunity afforded by the study during the hands-on practical activity by Cirhakazi. Thus, there was a positive shift in teachers' ZPD as espoused by Vygotsky (1978) in terms of linking IK to WS.

8.2.3 Exposed to learning opportunities on how to use IK in certain science topics

The findings of the study suggest that the science teachers were exposed to learning opportunities that showed them how to use IK in certain science topics. For example, Madiba stated: *"I have learned a better approach to explain Le Chatelier's Principle and rates of chemical reactions and I could use IK in other topics, I just need to research and prepare"*. In a similar vein, MaNgconde said: *"I have seen how IK was used during the demonstration, I*

have learned how to use IK in science, and I will try and integrate IK in other science topics, it helps to explain difficult science concepts". Indeed, the transformation research paradigm enabled the IKC and the science teachers to work in harmony as a family (Chilisa, 2012) and transformative learning took place as revealed in the above comments. MaMhegeba mentioned that: "…. *we use mixtures in our daily lives".* MaMyeka highlighted that:

> *Another thing that impressed me was when she cooked and the water ran out before the bread was properly cooked she added hot water to maintain the equilibrium, she explained that if she added cold water the bread will be damp as she would have disturbed the equilibrium, the point she made was that IK could be used when teaching chemical equilibrium.*

I realised that these responses revealed that one could use easily accessible resources to illustrate a point (Asheela et al., 2021; Shinana et al., 2021) and that IK could be in the form of everyday prior knowledge (Kuhlane, 2011) like making homemade bread (*isonka samanzi*) similar to Nandjedi's (2022) study conducted in Namibia. Based on these comments, the participants acknowledged that learning opportunities were created in this study. This finding resonates with Ngcoza and Southwood's (2019) view that emphasises the importance of a participatory and emancipatory approach (like Lesson Study) to teacher professional development that is based on mutual and collaborative support.

8.2.4 Learning affordances provided by hands-on practical activities

Referring to her shortcomings in making homemade bread (*isonka samanzi*), MaMyeka stated: *"MaMcirha did not have the measuring tools, but she knew the exact quantities that she must add, this was my first mistake, I did not know the measurements"* – she continued and said: *"My second mistake was to use hot water instead of lukewarm water".* This comment reveals that the practical presentation by MaMcirha afforded MaMyeka an opportunity to learn and identify her own mistakes which resulted in her homemade bread being damp. This seems to indicate the value of tapping into the cultural heritage of community members (Klein, 2011; Mateus & Ngcoza, 2019). It could be surmised, therefore, that the study provided a learning space for MaMyeka.

On the other hand, Zizi said that: *"I have learned so much from MaMcirha, I think I can now confidently try to make the homemade bread or teach others".* Madiba said a mouthful when he said: *"The is no doubt in my mind that we need IK and elders to help us in science, so I would say we need to invite even bush mechanics to explain topics like AC and DC motor".*

Traditionally in the African culture, gender and cultural stereotypes regard cooking as a role reserved for women (Amutenya, 2023; Mthembu et al., 2023). Based on Zizi's comment and the lessons that we learned from MaMcirha's insightful presentation, the study recommends that this view be reviewed and calls for gender and culturally responsive teachers (Mthembu et al., 2023). Along the same line, MaMhegeba indicated: *"How I so wish to use MaMcirha in my own teaching practice which will need indigenous knowledge".* Essentially, the study revealed that the practical presentation by MaMcirha enabled the science teachers to make links between IK and WS (Shinana, 2019). In other words, the study provided space for science teachers to relate what the learners learn from home to what they learn at school, thus making science accessible and relevant.

This study revealed that learning opportunities were co-created during the presentations by the IKCs and that learning opportunities were co-created during the hands-on practical activity on how to make homemade bread. Like Shinana (2019) who worked *with* science teachers to mobilise *oshikundu* to mediate the learning of enzymes and promote inquiry-based approaches and Simasiku's (2022) study that used a peer-learning community and IKCs to mediate learning of rates of reactions, findings of this study revealed that science was contextualised, resulting in greater conceptual learning and hence sense-making of the key scientific concepts developed.

8.3 Reflective Space

Moreover, like Liveve's (2022) and Simasiku's (2022) studies conducted in Namibia and consistent with Indigenous research methodologies as reiterated by Chilisa (2012) and others, we also ensured the trustworthiness of the data by reflecting and co-presenting our findings to our IKCs. Also, in line with Ubuntu, it was crucial to give feedback to the participants who helped me to complete this project. We also allowed the IKCs to reflect on their experiences of being involved in this study. This was done to give voice to all the participants involved in this study. This reflective space and final session took place on the school grounds (see Figure 8.3 below).

Figure 8.3: A reflective space with research participants and IKCs

The session was video recorded with the participants' permission and I also took some notes. I also invited my supervisor (Gxarha) who kindly joined us so that he could get firsthand experience of our PLC and the IKCs. The general feeling of the science teachers who participated in this study during this reflective space was that they found the study to be very empowering. They also agreed in unison that there is a place for IK in science teaching. Most importantly, they learned that there is a need to involve community elders in other science topics. I also observed that the IKCs who participated in this study appreciated hearing the teachers' comments and they felt honoured. For instance, MaMcirha said:

> *Ngokuya ndandicelwa ukuba ndizokubonisa otitshala ukwenziwa kwesonka samanzi, khange ndazi ukuba ndiyancedisa kwezemfundo, ngoku xabethetha ngoluhlobo ndiyavuya kakhulu kwaye ndiva kamnandi kakhulu (When I was invited to come and show the teachers how to make homemade bread I did not know that I would be contributing to education, and now when I hear the teachers speaking like this I am very happy and I feel appreciated).*

Similarly, Majeke indicated: "*Kumnandi xa abazali benikwa ithuba lokuba babenegalelo kwimfundo nabo, ndiva kamnandi kakhulu*" (It is nice when parents are allowed to contribute to the education of their children, I am very happy to be involved). He further indicated in isiXhosa that many parents in the community have knowledge and skills, such as motor mechanics, builders, tilers and woodworkers and suggested that the school should invite them as well. It seems that his suggestion was well received by the teachers as I saw some nodding and others saying that it was true. It was interesting to hear such profound advice from someone who has no formal education and hence is perceived as 'uneducated'.

In a similar vein, Umhlekazi (the traditional healer) commented in isiXhosa that he was pleased to be part of the study and applauded the school for not looking down on traditional healers and community members. He also indicated that he felt appreciated and valued when he said: "*Ndiyavuya xa isikolo singasijongeli phantsi nathi siziva sixabisekile kakhulu*" (I am so delighted to see that the school does not look down upon us and that we are also respected). Umhlekazi also highlighted the importance of encouraging abathwasi (those that are called by ancestors) to value education and encouraged the school to embrace them. He further explained that it was important for the Sangomas to be able to communicate in English so that they could share their knowledge with the health sector and be able to help White people as well during consultations.

In terms of using their photographs in the thesis, Umhlekazi responded as follows: "*Kukho iincwadi ezibhalwe ngoSteve Biko nezibhalwe ngoMandela nabanye zinobuso babo, ngenxa yalonto bayaziwa nangabazukulwane, nathi sifuna lonto mzifakwe ifoto zethu singafihlwa sihlwele*" (There are books written by Steve Biko and others written about Mandela and other leaders with their pictures, because of that even the grandchildren know them, for that reason we also want our photos to appear in the thesis). Others agreed and said: "*Injalo, mazifakwe singafihlwa*" (That is true, we want our pictures to be included in the thesis and our faces should not be hidden). I found these sentiments by the participants very encouraging and in line with the indigenous research paradigm.

8.4 Data from Hands-on Practical Activities and Visualisation by Nozinga

This session was about redox reactions and other related concepts to broaden the teachers' knowledge. This is in line with the LS approach and resonates with Lenski's et al. (2009, p. 50) view that "LS is a professional development vehicle for improving instructional practices

in township schools". Indeed, the professional development of the science teachers was a key aspect of this study. The data gathered from Nozinga's practical demonstration helped me to answer my research question 4: *What learning opportunities are co-created (or not) during hands-on practical activities on kitchen chemistry?*

8.4.1 Introduction

Nozinga is a university lecturer and a critical friend. She and her chemistry students visited our school to do fun hands-on practical activities called Pollutants Tale[15] for our Natural Sciences learners. I approached her to do some hands-on practical activities to show the science teachers the importance and relevance of practical activities (Chikamori et al., 2019). Nozinga agreed and we set up the date and the time to visit her laboratory. When I informed our PLC about this arrangement, I saw smiles on their faces and some even indicated that it was going to be their first time in a chemistry laboratory. For instance, MaMpehle, our Foundation Phase teacher indicated: *"Andizange ndizenze ipracticals apha ebomini bam, yiyeke eyeyokuya elab"* (I have never done practical activities in my life let alone going to a chemistry lab). I found MaMpehle's comment very humbling. This confirmed my assumption that there was a need to expose the science teachers to doing hands-on practical activities. Indeed, Shulman (1987) reiterates that for teachers to be able to effectively mediate learning, they ought to know the best strategies (such as hands-on practical activities) to use to make content relevant and accessible to their learners. So, we went for redox reactions which was the focus of this study and in terms of capacity building, we went beyond the scope of the study to expand the knowledge of the participating teachers.

8.4.2 Using easily accessible resources to do hands-on practical activities

Unfortunately, MaMyeka could not attend because she was a BEd Honours student at Rhodes University, and they had a contact session on that day. We agreed that she had to focus on her own studies. Instead, Hlathi, a newly appointed temporary educator requested to join us because he wanted to develop himself and we agreed. Also, my supervisor Gxarha and his colleague Ingwe who is an ICT lecturer and his PhD student joined us. Since Ubuntu which focuses on sharing and mutual benefit (Seehawer, 2018) was the relational philosophy

[15]Pollutant's Tale is the name given to hands-on practical activities based on gases of the air such as carbon dioxide; nitrogen and oxygen to foster understanding of climate change. These are also intended to ignite passion for science amongst learners.

underpinning this study, we could not deny them the opportunity to learn. This is contrary to the Eurocentric methodological approach which highlighted the cultural tension between the European and African way of doing things.

On arrival at the university, Nozinga warmly welcomed us and without wasting time she motioned that *"the worksheets* (see Appendix M) *are there and everything you will need for today's activities are there, we are going to start; you are a group of eight so each person can work on their own"*. I noticed that MaMpehle, who was a Foundation Phase teacher, looked nervous. I remembered that earlier on she indicated that she had never done practical activities before, so I offered to work with her so that she could feel more comfortable. In this regard, Stott (2016) emphasises the importance of peers being MKOs as well. I did this out of Ubuntu because in the African culture, no one is left behind, and as a chemistry major (MKO) I was familiar with these practical activities (Stott, 2016). Therefore, we worked together until I could see that she was confident to work on her own. After the second activity, I could see that she was enjoying herself and I left her to work on her own. It is worth mentioning that after I left her to work on her own, I noticed that she was always the first to share her readings and observations with the rest of the group. To me, this suggests that her ZPD had shifted (Vygotsky, 1978) as she was able to work without the MKO. This is new knowledge where a Foundation Phase teacher worked with a grade 12 science teacher and gained the confidence to be able to work independently.

Figure[16] 8.3: Showing some of our PLC members in a Chemistry Lab

[16] The participating teachers consented for their photographs to be used in the thesis and requested its copy.

Nozinga explained how we were going to work with endothermic and exothermic reactions using easily accessible resources as reiterated by Asheela et al. (2021). She continued to explain that we were going to answer some questions through practical investigations and said: *"Do they produce heat, or do they use up heat for the reaction to go and that's what we going to be looking at"*. Nozinga further explained:

> *It is all kitchen chemistry except for concentrated sulphuric acid, the rest you can all buy at any supermarket, so you can actually go and do it with your class without having great expense or without needing a lab.*

In other words, we were going to use easily accessible resources to mediate learning. Lack of resources is reported to be one of the restraining factors that contribute to the failure to do practical activities in township schools in South Africa and Namibia (Asheela, 2017). Before starting with the practical activities, however, Nozinga gave a short presentation on their background:

> *Chemistry has a lot to do with symbols, chemistry is often divided into three dimensions. First one is macro, second is micro and the last one is symbolic. What we need to do as chemists is to try and move between the three dimensions, we also need to take it to account that our students cannot move that fast. I often borrow people my recipe book and they would ask what is going on because I write H_2O and they can't understand the symbols, they can't move between macro and symbolic. We use symbols to absolute everything. The symbol we are going to use today ΔH (Delta H), Δ stands for change and H for the heat of reaction and so we going to work today with that, when something cools down we say its endodermic and ΔH is positive when its exothermic we say ΔH is negative, so that's the symbol we going to work with today and you will see that I've put the symbols and some of the reactions in so that you could see the chemical equation, so we going to move between macro and symbols we are not going to look at the molecules in molecular phase.*

I found Nozinga's introduction most intriguing and enlightening in the sense that it exposed the relationship between the three dimensions of chemistry. Also, it revealed the importance of taking the learners through the activity before starting the practical activity to avoid the uncritical use of hands-on practical activities (Asheela et al., 2021). Therefore, it was imperative for Nozinga to give a clear background before starting with the practical activities. After this brief and very informative presentation, she explained that we were to read the introduction and thereafter start with the first activity, and then we would compare notes to see what our results were. I observed that the science teachers were enjoying themselves as shown in Figure 8.4 below and that social interactions and active engagements were taking place during the hands-on practical activities as teachers were sharing their findings.

Figure 8.4: Showing science teachers sharing their findings

Nozinga prepared a worksheet on hands-on practical activities for our PLC with clear instructions – all the equipment necessary was available (see Appendix X). We did all the practical activities on our own except the last one on sugar and sulphuric acid and thereafter shared our findings. Nozinga explained that the last activity using sulphuric acid and sugar was very dangerous. She kindly did the demonstration for us. In this demonstration we observed that when you added the sulphuric acid to the sugar there was a change in colour in the sugar; the sugar changed to the dark colour as shown in Figure 8.5 below.

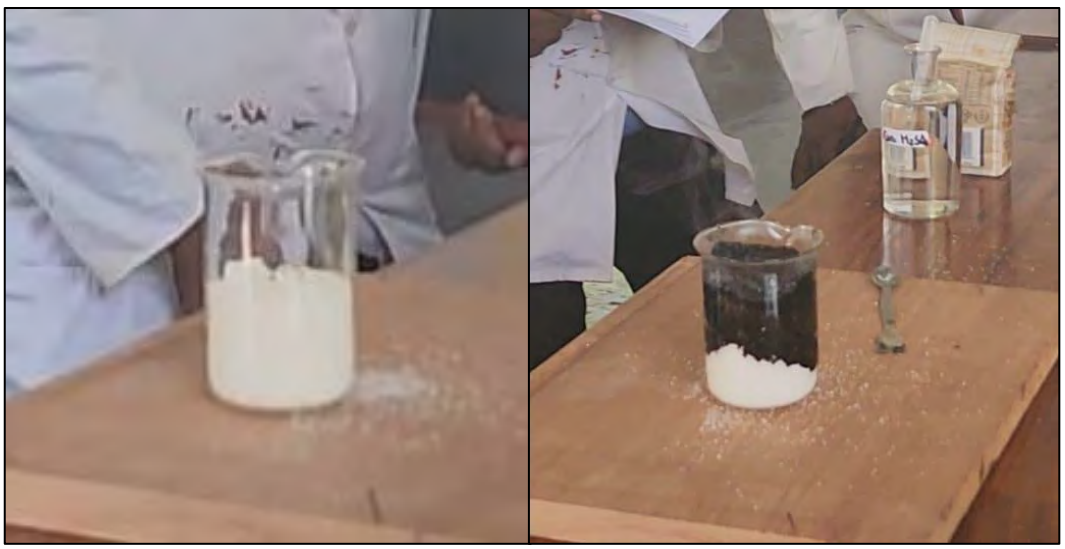


Figure 8.5: Showing the colour change in the sugar after adding sulphuric acid

Nozinga explained that the black stuff we saw was carbon and that this demonstration was referred to as a volcano experiment as it resembled a volcano. We also observed that a gas was given off and we later learned that the gas was sulphur dioxide (SO_2). Sulphur dioxide is a very important part of acid rain when we talk about climate change. I observed that the teachers were listening attentively and showed keen interest. For instance, Hlathi asked a question: *"Nozinga you said we must not touch sodium hydroxide pallets with our hands why not?"*. Nozinga responded and said: "*It is because as soon as it touches your hands it will react with the moisture on your hands, and it is a very strong base, and it will burn you*". Personally, as a participatory observer, I believe my teaching approach was influenced by the practical activities. After the session, we thanked Nozinga and left.

8.4.3 Use of easily accessible resources stimulates excitement and promotes learning

This theme is supported by the following teachers' reflections. MaMpehle said: *"Bekumnandi kakhulu, binika umdla kakhulu andifuni kuphosisa"* (I had fun, the presentation was interesting I don't want to lie). Likewise, MaMhegeba reflected: *"I have enjoyed all the practical activities and it dawned to me that science is living and exciting"* and Madiba indicated: *"Nozinga's approach was very exciting, and I have gained ideas of how to do practical activities better"*.

Based on the above reflections by the science teachers it seemed that they enjoyed the practical activities and had gained from this experience. These responses draw our attention to the need to support teachers in developing science lessons that integrate IK using easily accessible resources (Asheela et al., 2021). This observation was illuminated by the following reflections:

> *I noticed that teachers were excited during the experiments, that gave me an idea that we could bring the excitement to the learners by doing these kind of practical activities, the learners will be able to remember in a test and answer properly.* (Hlathi)

> *I have learned that doing science in the kitchen can be enjoyable and that learners can go home and explain to their mothers the science concepts, for example when they do umqombothi (African beer).* (MaNgconde)

The study revealed from the excerpts above that one of the co-created learning opportunities during hands-on practical activities on kitchen chemistry was gaining a better understanding that the use of easily accessible practical activities stimulates excitement and promotes learning. This resonates with Ngcoza et al.'s (2016) conclusion that learners who participate in interesting hands-on practical activities become more motivated to study science at school.

8.4.4 Enabling and supporting learning

The science teachers participating in this study suggested that the use of easily accessible practical activities enabled and supported learning. This theme is supported by the following excerpts.

> *I have learned today that you can do a communicative approach, let the learners do the experiments and tell you what they have learned as we did today.* (MaMhegeba)

> *We need to bring science to the learners, we have seen today that we do not need high-tech labs and chemicals, so it is doable as long as you as a teacher you prepare well.* (Hlathi)

> *When I added too much acid instead of a drop, smoke started to show and the container was hot, I have learned to be careful when working with acids and follow the instructions carefully.* (MaMpehle)

> *Iscience mhlawumbi sithi thina botitshala abenza abantwana bayoyike, ngoba asibakhuthazi ukuba baze nalo knowledge from ekhaya* (Maybe it is us teachers who make learners to fear science because we do not encourage them to bring knowledge from home). (Mangconde)

This shows that practical activities could be used in class to excite the learners. Moreover, the science teachers appreciated the practical activity using vinegar and steel wool which are readily available in kitchens to explain redox reactions. Aikenhead and Jegede (1999) view this as something that enables learners to cross the cultural bridge between home experiences and school science. Madiba took it to another level as the curriculum manager of the school and suggested that *"I have learned that we can have a science show at school before we teach the topic on physical and chemical change, which is found throughout the syllabus, from these concepts will emerge, we must explore this at school".* He seemed to have the support of the teachers as they were nodding, some saying "yes". The study, thus, concludes that exposure to easily accessible practical activities had a profound impact on the science teachers involved in this study.

8.4.5 Power of practical activities as a learning affordance

An analysis of the participating science teachers' reflections revealed that there was a shift in the ZPD and PCK regarding their understanding of practical activities. This shift was evident in their reflections as stated below.

> *We must give our learners space to learn from their mistakes … It is very important to identify the do's and don'ts, for example, I have learned from my mistake that you cannot touch the thermometer at the tip otherwise it gives you a wrong reading*. (Zizi)

> *Using easily accessible resources will make science interesting for learners and they can bring the knowledge from home (bread making) to class, that will make them learn and pass science. Thus, closing the gap between home and school*. (MaNgconde)

The above comments by the two teachers reminded me that literature reveals that hands-on practical activities when carefully planned provide opportunities for learners to use everyday and local materials, especially in school contexts where there is a lack of resources (Asheela et al., 2021). Woodley (2009) also sees practical activities as a bridge between what learners can see and do and the scientific concepts that emerge as was the case in Zizi's situation. In other words, hands-on practical activities are powerful in promoting conceptual development and understanding of science concepts (Asheela et al., 2021). Moreover, MaMhegeba suggested the following:

> *When teaching the particle model you can use the learners for demonstration, for example, you can tell them to come closer together, then move a little bit away from each other, then move further away from each other, to explain the particle model in solids, liquids and gases*.

From this comment, one can tell that she was longing to use ideas that could make science accessible to learners. Essentially, the science teachers found hands-on practical activities a vehicle that could be used to enable the learning of science. I also found the easily accessible practical activities very useful, and I am very grateful to Nozinga. However, when I introduce them to my learners, I will bring in an element of predictability and ask my learners to write their own reflections afterwards.

8.5 Chapter Summary

This chapter explored the learning opportunities created by the two practical demonstrations by an IKC and a critical friend. I thus presented the data generated from each practical demonstration lesson and analysed the learning opportunities provided. The data gathered in this chapter revealed that multiple learning opportunities were created by the study because teachers were able to generate innovative ideas on how to tap into community members' IK, how to draw links between IK and science and how to conduct practical science lessons using easily accessible resources.

In addition, evidence from the teachers' comments revealed a shift in the teachers' ZPD in terms of the integration of IK and a shift in teachers' PCK in terms of understanding how to do practical activities using easily accessible resources. It is clear that as township science teachers, we need to develop our own resources to make science relevant and accessible to our learners.

CHAPTER NINE: CO-DEVELOPMENT AND ENACTMENT OF EXEMPLAR LESSONS

> The collaborative planning and debriefing of research lessons provide teachers with learning opportunities through shared classroom experiences in which certain aspects of teaching and student learning may be highlighted and reflected upon as a group. (Lee & Tan, 2020, p. 2)

9.1 Introduction

This chapter deals with the exemplar lesson on redox reactions and the exemplar lesson on waves and sound. I present and analyse data for research question 5:

> How do science teachers co-develop and then enact their own exemplar lessons that integrate Indigenous Knowledge on waves, sound, and redox reactions?

This research question was addressed in the last two phases of this study (see Section 4.6.4) and is the key focus of this research. The qualitative data collected was analysed using thematic data analysis to identify sub-themes and themes. To achieve this, I followed Nhase et al. (2021), writing narrative stories from all the participants' responses. Videos were transcribed and episodes emerged from the data. The videos were also used for stimulated recall discussions which validated the data because I had an opportunity to ask further questions and seek clarity. The strategy of writing narrative stories from the data was a method of making sense of the data from both interviews and observed lessons.

Lastly, the raw data from the video-recorded lessons, observations and stimulated recall interviews, group reflections and science teachers' reflective journals were used to understand the events that took place when the teachers taught in their classrooms. Furthermore, the study sought to understand the teachers' pedagogical experiences of using a Lesson Study approach and integrating IK to mediate learning on the topics of waves and sound and redox reactions in a township school. The two teachers volunteered to teach these lessons.

Now, in this phase of the research and consistent with the Lesson Study approach, we conducted observations of two lessons (on the same topics, taught by the same teachers), after we had developed exemplar lessons that integrated IK to see how the science teachers enacted them. The lesson observations were crucial in this study in that they served as a window to showcase the effect of the workshops on IK integration and the importance of hands-on practical activities (Asheela et al., 2021). That is, we wanted to see if there had been a shift in teachers' ZPD and/or PCK in terms of the integration of IK in the lessons that we co-developed.

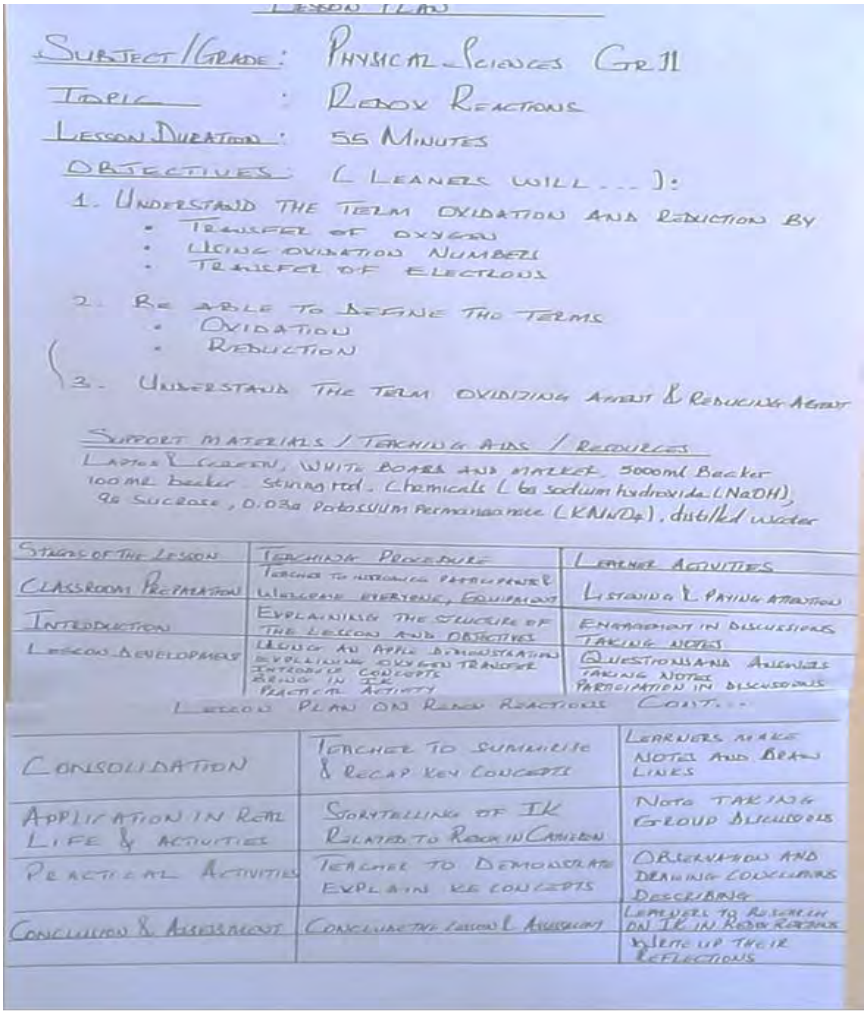
During lesson observations I wrote some field notes, and two other teachers video recorded the lessons with the consent of the participating teachers. After the lesson observations we arranged to watch the videos in our PLC and engaged in stimulated recall discussions. As indicated (see Section 4.6.5) in this study, stimulated recall discussions were done in the form of talking circles (Chilisa, 2012) or sharing circles (Lavallee, 2009) which is in line with the Indigenous research paradigm employed in this study. Next, I first briefly discuss the co-development of exemplar lessons by our PLC.

9.2 Co-development of Exemplar Lessons

Research question 5 has two parts. The first part of the question sought to know how the science teachers co-developed the exemplar lessons while the second part sought to understand how the science teachers presented their exemplar lessons that integrated IK into the topics of waves and sound and redox reactions respectively after they had been developed. The aim of this section is to answer the first part of the question.

Drawing on Lee and Tan (2020), our PLC was divided into two groups, that is Group 1 (G1) and Group 2 (G2) to engage teachers in collaborative work as mentioned in the epigraph. G1 focused on redox reactions and G2 focused on the topic of waves and sound and co-developed their lesson. Moreover, we wanted to give the participating teachers an opportunity to experience firsthand how to go about co-developing their exemplar lessons that integrate IK and an opportunity for continuing professional development (CPD) (Ngcoza & Southwood, 2019; Seehawer, 2018a). Each group had one teacher from the Foundation Phase, one Intermediate Phase, one teacher from the Senior Phase and one teacher from the Further Education and Training (FET) Phase.

After the group engagements, each group wrote their lesson plan and presented it to the entire PLC for comments or suggestions for improvement. What was done differently in this study was that after the refining process by the PLC, the two science teachers who taught the pre-intervention lessons were given an opportunity to personalise the lesson plan and then teach the lesson again, so that we could observe the shift in terms of IK integration. Shown below are examples of the lesson plans that were collaboratively co-designed by G1 and G2 respectively.



LESSON PLAN

SUBJECT/GRADE: PHYSICAL SCIENCES GR 11

TOPIC: REDOX REACTIONS

LESSON DURATION: 55 MINUTES

OBJECTIVES: (LEARNERS WILL...):

1. UNDERSTAND THE TERM OXIDATION AND REDUCTION BY
   - TRANSFER OF OXYGEN
   - USING OXIDATION NUMBERS
   - TRANSFER OF ELECTRONS
2. BE ABLE TO DEFINE THE TERMS
   - OXIDATION
   - REDUCTION
3. UNDERSTAND THE TERM OXIDIZING AGENT & REDUCING AGENT

SUPPORT MATERIALS / TEACHING AIDS / RESOURCES

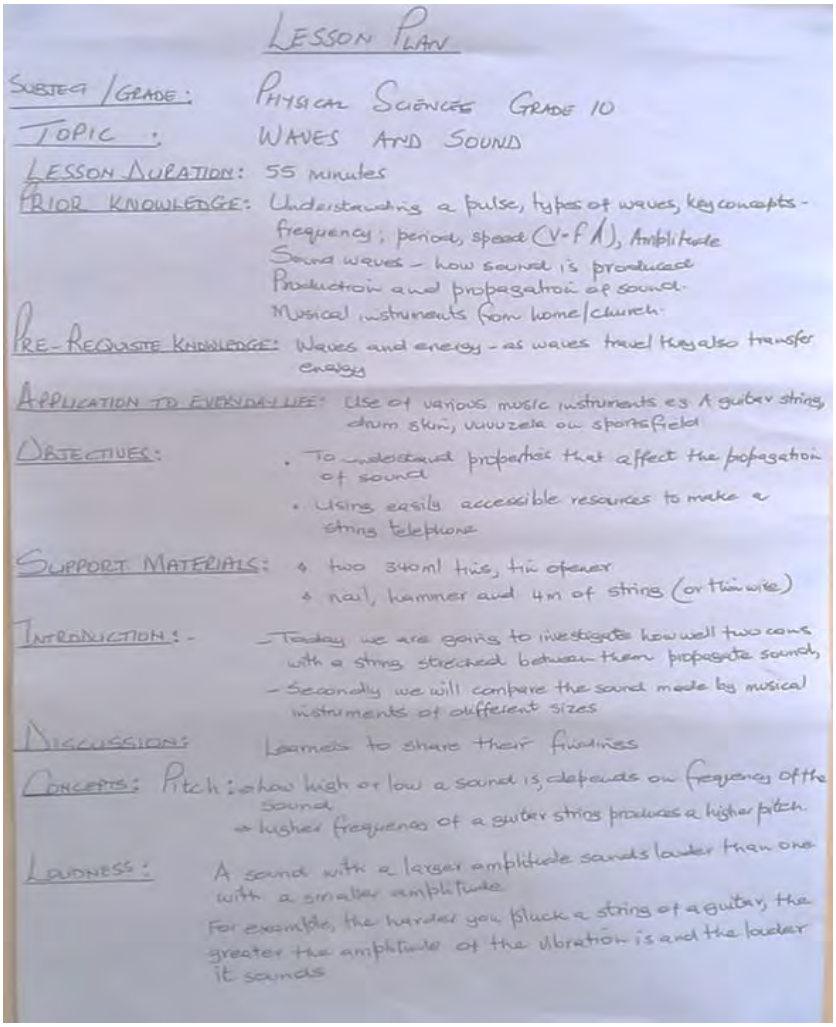
LAPTOP & CHARGER, WHITE BOARD AND MARKER, 5000ml Beaker 100 ML beaker stirring rod. Chemicals (6g sodium hydroxide (NaOH), 9g Sucrose, 0.03g Potassium Permanganate (KMnO4), distilled water

STAGES OF THE LESSON	TEACHING PROCEDURE	LEARNER ACTIVITIES
CLASSROOM PREPARATION	TEACHER TO INTRODUCE PARAPHERNALIA WELCOME EVERYONE, EQUIPMENT	LISTENING & PAYING ATTENTION
INTRODUCTION	EXPLAINING THE STRUCTURE OF THE LESSON AND OBJECTIVES	ENGAGEMENT IN DISCUSSIONS TAKING NOTES
LESSON DEVELOPMENT	USING AN APPLE DEMONSTRATION EXPLAINING OXYGEN TRANSFER INTRODUCE CONCEPTS BRING IN THE PRACTICAL ACTIVITY	QUESTIONS AND ANSWERS TAKING NOTES PARTICIPATION IN DISCUSSIONS

LESSON PLAN ON REDOX REACTIONS CONT...

CONSOLIDATION	TEACHER TO SUMMARISE & RECAP KEY CONCEPTS	LEARNERS MAKE NOTES AND READ LINES
APPLICATION IN REAL LIFE & ACTIVITIES	STORYTELLING OF IK RELATED TO ROCK IN CAMEROON	NOTE TAKING GROUP DISCUSSIONS
PRACTICAL ACTIVITIES	TEACHER TO DEMONSTRATE EXPLAIN KEY CONCEPTS	OBSERVATION AND DRAWING COLOURS DESCRIBING
CONCLUSION & ASSESSMENT	CONCLUSIVE REMARKS & ASSESSMENT	LEARNERS TO RESEARCH ON IK IN REDOX REACTIONS WRITE UP THEIR REFLECTIONS

Figure 9.1a: Lesson plan on redox reactions



LESSON PLAN

SUBJECT / GRADE: PHYSICAL SCIENCES GRADE 10

TOPIC: WAVES AND SOUND

LESSON DURATION: 55 minutes

PRIOR KNOWLEDGE: Understanding a pulse, types of waves, key concepts - frequency; period, speed (v = f λ), Amplitude
Sound waves – how sound is produced
Production and propagation of sound.
Musical instruments from home/church.

PRE-REQUISITE KNOWLEDGE: Waves and energy - as waves travel they also transfer energy

APPLICATION TO EVERYDAY LIFE: Use of various music instruments eg A guitar string, drum skin, vuvuzela on sportsfield

OBJECTIVES:
- To understand properties that affect the propagation of sound
- Using easily accessible resources to make a string telephone

SUPPORT MATERIALS:
- two 340ml tins, tin opener
- nail, hammer and 4m of string (or thin wire)

INTRODUCTION:
- Today we are going to investigate how well two cans with a string stretched between them propagate sound,
- Secondly we will compare the sound made by musical instruments of different sizes

DISCUSSION: Learners to share their findings

CONCEPTS: Pitch: how high or low a sound is, depends on frequency of the sound
→ higher frequency of a guitar string produces a higher pitch.

LOUDNESS: A sound with a larger amplitude sounds louder than one with a smaller amplitude
For example, the harder you pluck a string of a guitar, the greater the amplitude of the vibration is and the louder it sounds

Figure 9.1b: Lesson plan on waves and sound

- **Brief analysis of the co-designed lesson plans**

An overview of the two lesson plans revealed several things. Both lesson plans show that the teachers were aware of the importance of the learners' prior knowledge. However, how such knowledge would be used to enhance the teaching and learning of the two topics was not elaborated on. In line with the main goal of this study, both lesson plans indicated the integration of IK as one of the objectives of the lesson, which suggests that the teachers seemed keen to make science relevant and accessible to the worldview of the learners. It would be interesting to see how teachers used the learners' prior knowledge and how they linked the local knowledge to waves and sound and redox reactions respectively when they enacted their lessons and how these influenced the teachers' PCK and learning of the two topics.

Next, I give a short narrative of each lesson I observed from each participant in this study followed by the presentation and discussion of the episodes (Nhase, 2019) that emerged from the data of the two participants – this is done with the aid of the analytical tool, literature, and theory. In other words, the videos were transcribed, and episodes emerged from the data. The videos were also used during stimulated recall discussions which validated the data because I had an opportunity to ask further questions and seek clarity.

9.3 Summary of the Lesson on Redox Reactions

As indicated above, this lesson was taught by Madiba. He was a qualified Physical Sciences teacher holding a BSc degree in Physics and Mathematics as his majors and a Higher Diploma in Education (HDE). He had 14 years' teaching experience. So, the issue raised by some scholars that some teachers who teach science are unqualified teachers with little or no experience is ruled out. Also, worth mentioning is that Madiba is a deputy school principal at Buyelembo Combined School where the study was conducted and oversaw Physical Sciences and Mathematics. Madiba's lesson on redox reactions for the Grade 11 class was videotaped by my critical friend with the permission of the participants. MaMyeka and I focused on observation and took some notes. Madiba started by greeting the learners and explained that in class they were joined by the Grade 12 Physical Sciences learners for revision of the topic on redox reactions. The learners were given codes as pseudonyms namely L1-L20, where L1 was learner number 1, L2 was learner 2 and so on. He also explained to the learners that another science teacher, MaNgconde, had requested to join the lesson and she was going to videotape the lesson. He also informed the learners that Cirha had also joined the lesson as an observer.

Figure 9.2: Showing the class taught by Madiba

After this brief explanation he started the lesson as follows: *"Allow me to introduce the lesson and explain why we are here"*. He explained that he would be teaching a lesson on redox reactions. He further explained that on the table he had the following items: an apple, sugar, sodium hydroxide solution (not powder as expected because he did not have powder). He said: *"I took a liquid and I hope it will work"*. He also had potassium permanganate in powder form and asked: "A*re we still together*?" He also indicated that there was water in a beaker and said: *"It should be distilled water, but I am using water from the tap … I hope it will work"*. He explained that later he would be doing a practical demonstration using those things.

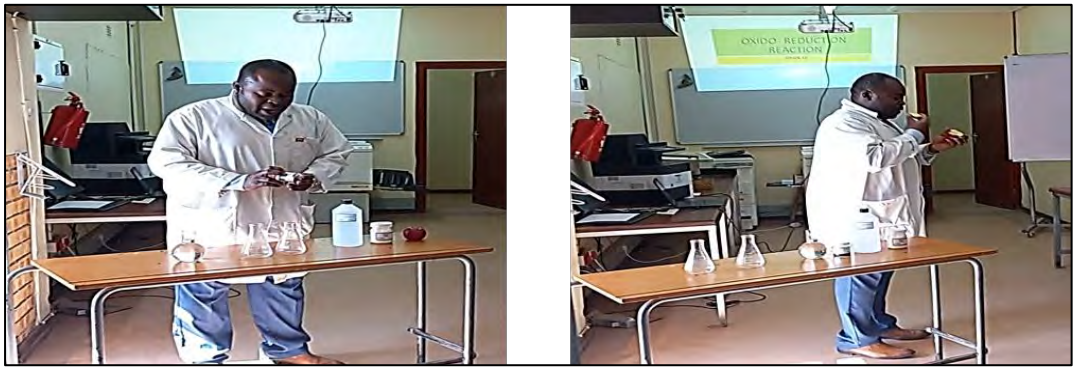


Figure 9.3: Showing Madiba presenting and demonstrating his lesson

Then he said: *"Let's start our lesson"*. He opened his PowerPoint presentation and proceeded with the lesson. He explained that the topic on redox reactions covered the grade 11 work. Next, Madiba took the apple, threw it into the air, caught the apple and took a bite, showed the learners the apple and asked them to look at the colour of the apple. Then he asked the learners a question: *"What do you think will happen to the colour of the apple after it has been left aside for 5 to 10 minutes?"* L1 responded and said: *"It will turn brown"*. Madiba acknowledged the learner's response by saying "*Right*" repeated what the L1 said, and said: "*She says it will turn brown"* and asked a follow-up question: *"What do you think is the reason of the apple changing its colour after it has been set aside for 5 to 10 minutes?*" He paused, put the apple on the desk and said: *"Let's see what will happen to the banana on the shelf of a shop; after one week or two weeks what will happen to the banana?"*

Then he lifted an iron nail and asked: "*What do you think will happen to this nail or zinc roof after 5 or 10 years*?" The learners responded in unison and said: "*They will rust"*. To this, Madiba asked the learners: *"Why will they rust; what is the rationale behind it? What is the scientific explanation?"* L2 responded and said: "*Because it is exposed to air and maybe*

water". Madiba said, "*That is a very interesting answer; I like it,"* and then said: *"On that note today we are about to discover a new topic called redox reaction and a deeper understanding of why an apple or banana changes colour and why an iron nail or zinc changes colour after 5 to 10 years".* He went back to his presentation and read the objectives of the lesson.

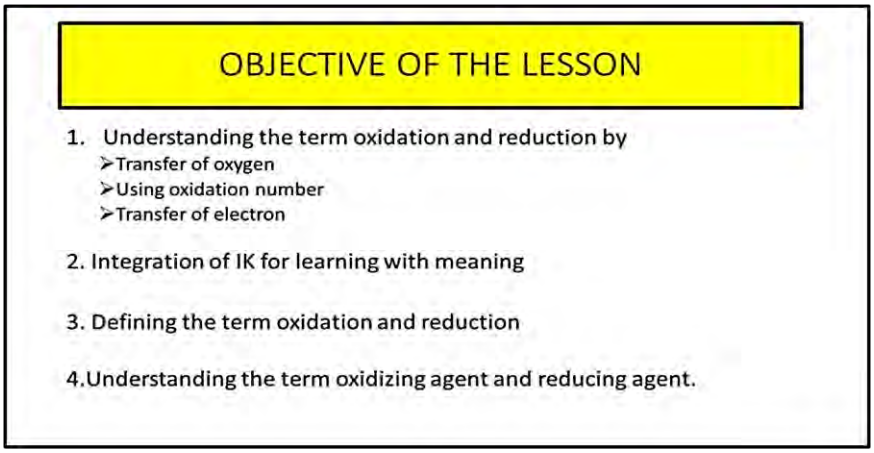


Figure 9.4: Showing the objectives of the lesson

Next, Madiba presented a slide that spoke to the definition of oxidation and reduction in terms of oxygen transfer. He explained these definitions were going to help the learners make sense of or understand why the apple, banana or iron nail changed colour.

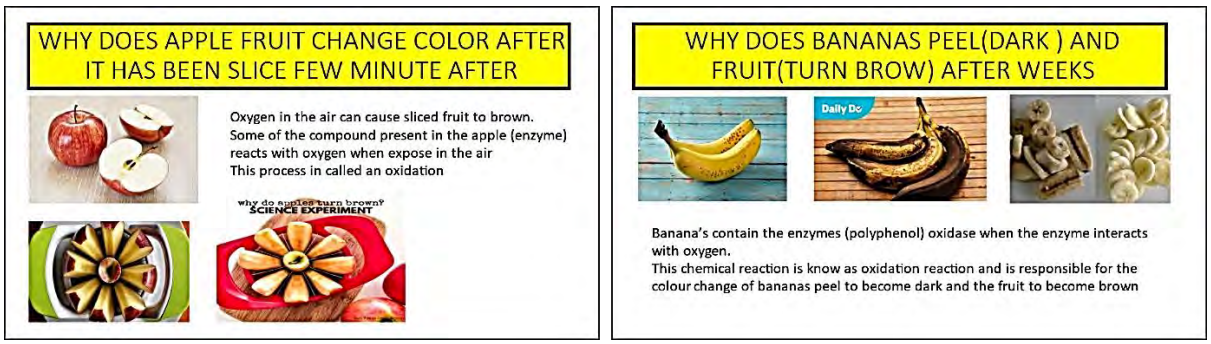


Figure 9.5: Showing the colour changes of various fruits during oxidation

Madiba clarified that one of the reasons for the colour change had something to do with enzymes: *"That is Biochemistry; don't worry about that at this stage; you will learn about it at university next year"*. He further elucidated: "The colour change occurs when the apple or iron nail reacts with oxygen". He emphasised that when a substance reacts with oxygen that is called oxidation in science. After this explanation, Madiba asked a question*: "How can you tell that oxidation has taken place in the case of a banana that has been on a shop shelf for a week or two?"* L2 responded and said: *"The colour of the banana skin changes and becomes dark"*. Madiba indicated that the same happened to zinc roofs or iron nails because it has been exposed to oxygen and water, then after a certain number of years turns brown, or it rusts. He further explained: *"Quite often when a substance comes into contact with oxygen a chemical reaction takes place, and we refer to this as oxidation"*. He continued to explain the reverse reaction which is called reduction and was taking place simultaneously with oxidation. He concluded and said: *"That is why the topic is called oxido-reduction or redox reactions"*. Madiba said: *"In other words these two half-reactions – one oxidation and the other reduction – are added together to produce the net redox reaction"*.

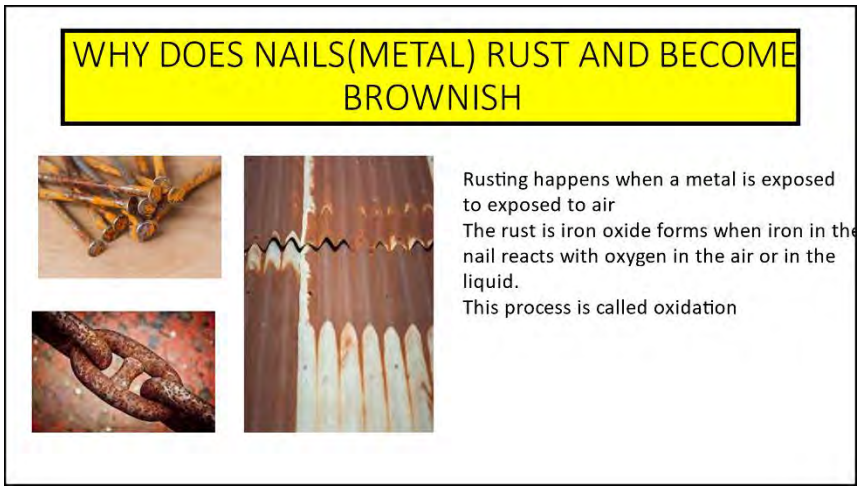


Figure 9.6: Showing metals rusting

Referring to the above slide Madiba said: *"Now you have discovered something new, that is science in our everyday life?"* He lifted the apple again and showed the learners and asked: *"What do you see now? Can you explain your observations?"* L3 responded and said: "*I see that the part of the apple that was eaten changed colour to brownish and that is because that part is exposed to air, so the apple reacted with oxygen"*. The class applauded him, and I heard one learner saying: *"Hayi uyibambile mntakwethu"* (You got it, my brother). Madiba said: *"Yes and we call that type of reaction oxidation"*. At this point, Madiba went back to his presentation

and showed the extraction of iron from iron ore. Pointing to the slide he asked the learners to take a closer look at it and he said:

> *Many of our people have been brainwashed that science does not come from Indigenous people. Our ancestors were scientists, and we were taught that science comes from the other side of the sea, the Western people; but I will prove to you that we have been brainwashed … Now let us discover what our ancestors knew.*

Figure 9.7: Showing how the ancestors extracted iron from iron ore

Pointing to the slide, Madiba told the learners that the people they saw were his forefathers from Cameroon; he said: *"Those were our forefathers who lived before Christ came on earth"*. He continued to tell the story:

> *Look what our forefathers were able to do, do you see what they were able to do? They were able to purify iron to develop their own tools, such as agricultural tools for ploughing and weapons, tools for their battles and for their own protection, therefore they had the skills and the technology needed, and that never came from the Western Countries.*

He continued:

> *Our ancestors were using this ancient technology way before the Western people arrived in our mother land Africa, before they colonised us, our forefathers even knew what we call raw materials and they boiled it an extremely high temperature, what we referred to in science today as the process of extraction. Our ancestors even made iron face masks for the African warriors when they went to war.*

After telling this story, Madiba said: *"Now let us pick up the science behind it"*. He proceeded with his presentation and said the next slide spoke to the definition of oxidation and reduction in terms of oxygen.

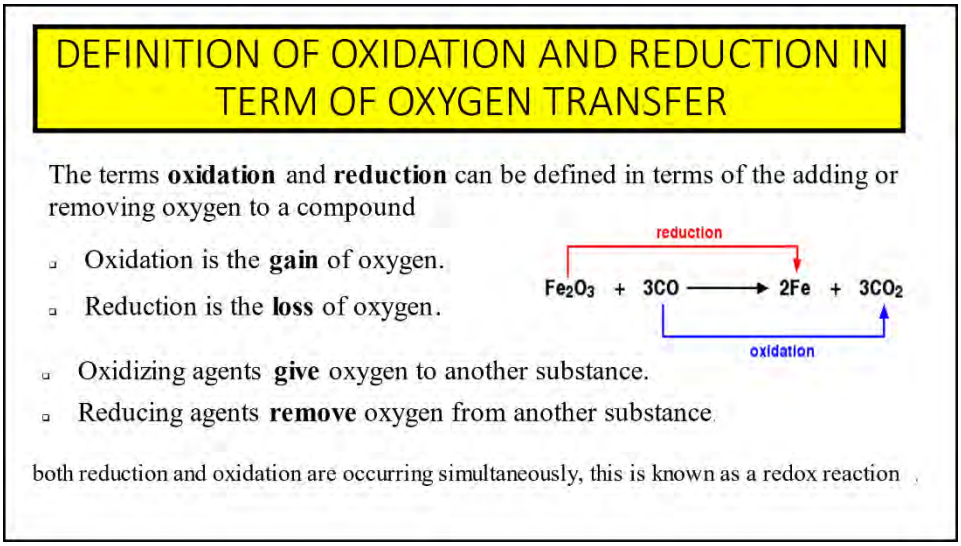


Figure 9.8: Showing oxidation and reduction in terms of oxygen transfer

He explained that the addition of oxygen to a compound is known as oxidation and the removal of oxygen from a compound is known as reduction. He emphasised that these two reactions were taking place simultaneously in a chemical reaction. To give more clarity, Madiba used the equation below to illustrate his point.

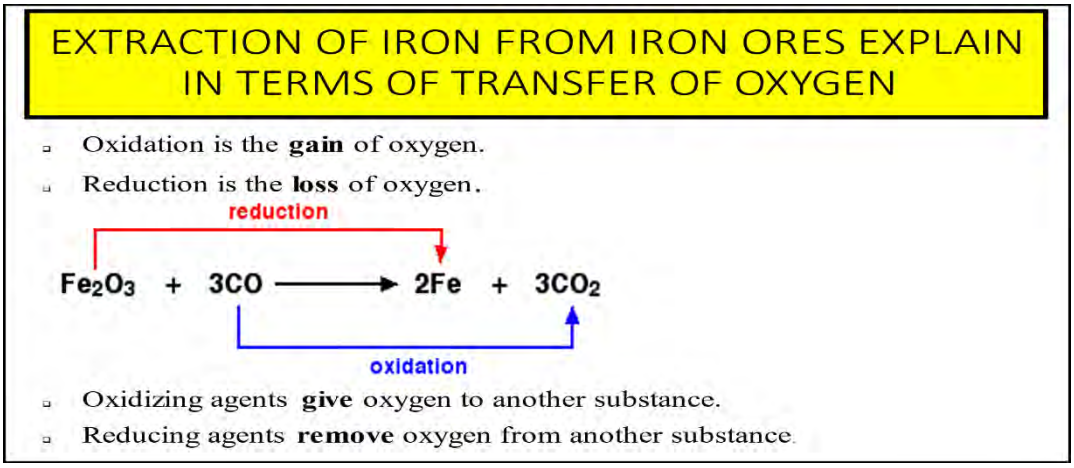


Figure 9.9: Showing the oxidising and reducing agents

He explained that on the left-hand side of the equation, we have iron oxide and on the right-hand side we have iron. Then he said: *"Would you agree with me based on this equation that our forefathers knew that you needed raw iron oxide to produce iron which was needed to make tools?"* He added:

> *Maybe they did not call this oxidation and reduction but from the fact that they knew which raw material to use and the know-how of changing it into iron, and the skill to make tools, so let us agree they knew science.*

I observed that the learners were paying attention and seemed to be interested in the lesson. Madiba used the equation to explain oxidation and reduction in terms of the gain or loss of oxygen or what he called oxygen transfer. From this explanation, he explained two new concepts: oxidising agent and reducing agent. He explained: *"In this context an oxidising agent is a substance that gives oxygen to another substance"* and he asked the learners to identify the oxidising agent in the equation. L4 responded and said: *"It's iron oxide because it is giving off oxygen*". Madiba agreed and said: *"Now the substance that accepts oxygen is called a reducing agent, and that is CO". H*e emphasised that these definitions were in terms of oxygen transfer.

Madiba shifted gears and moved on to explain oxidation and reduction in terms of oxidation numbers. He introduced his explanation as follows:

> *Let us go back to the question of why does a metal rust? In this case now, we are not going to use the transfer of oxygen but we will use oxidation numbers. But first let us see the link between the transfer of oxygen and the oxidation numbers using an equation and try to upgrade the definition of oxidation and reduction.*

He presented a new equation showing how iron combined with oxygen to form iron oxide as shown below:

$$Fe(s) + O_2(g) \rightarrow Fe_2O_3(s)$$

He explained pointing at the new equation that oxidation occurs when the oxidation number of the atom has increased. For instance, the equation shows that the oxidation number of iron (Fe) has increased from zero (0) to positive three (+3). He instructed the learners to pay attention to the equation and then asked the learners: *"Are you following? Now if the oxidation number has increased which term do we use to explain that?"* Most of the learners responded in unison and said: "*It is oxidation".* From the learners' responses, I got the sense that the learners were learning during Madiba's presentation. Madiba said:

> *Now you have gained new knowledge because from the start of the lesson you learned oxidation as a gain of oxygen and now you know oxidation as a process whereby the oxidation number of an atom has increased, right, similarly then reduction occurs when the oxidation number of an atom decreases of becomes smaller.*

Then, Madiba explained that this was another form of definition of oxidation and reduction. Next, Madiba wrote another equation:

$$Fe \rightarrow Fe^{3+} + 3e^{-}$$

After writing this equation he said:

> *This time around we are going to try to explain the terms oxidation and reduction in terms of the transfer of electrons. Maybe you have a question, what electrons have to do with oxidation and reduction, don't worry that's what you are about to discover.*

I noticed from the learners' facial expressions that they seemed interested and were paying attention. He explained that he was going to take the learners from the oxidation numbers and show a link between oxidation numbers and electron gain or electron loss during a chemical reaction. Madiba explained, pointing at the equation above that in a process whereby an oxidation number of an atom or an ion increases there is a loss of electron(s). He further illustrated his point by using the equation and said:

> *Remember based on the equation the oxidation number of iron (Fe) was initially zero (0) as shown on the left-hand side of the equation, but now can you see that it is now positive three (+3) on the right-hand side? So, iron (Fe) has lost three electrons to become (Fe^{3+}), listen we are trying to make sense that when the oxidation number has increased what happened is that there was a transfer of electrons, that is oxidation has taken place. On the other hand, in a process whereby the oxidation number of an atom or ion has decreased there is a gain of electrons, that is reduction.*

I could see that the learners seemed lost. At this point, Madiba used a different approach to explain the gain or loss of electrons. He drew on the grade 10 syllabus the Lewis diagrams to illustrate the transfer of electrons as shown in Figure 9.9 below.

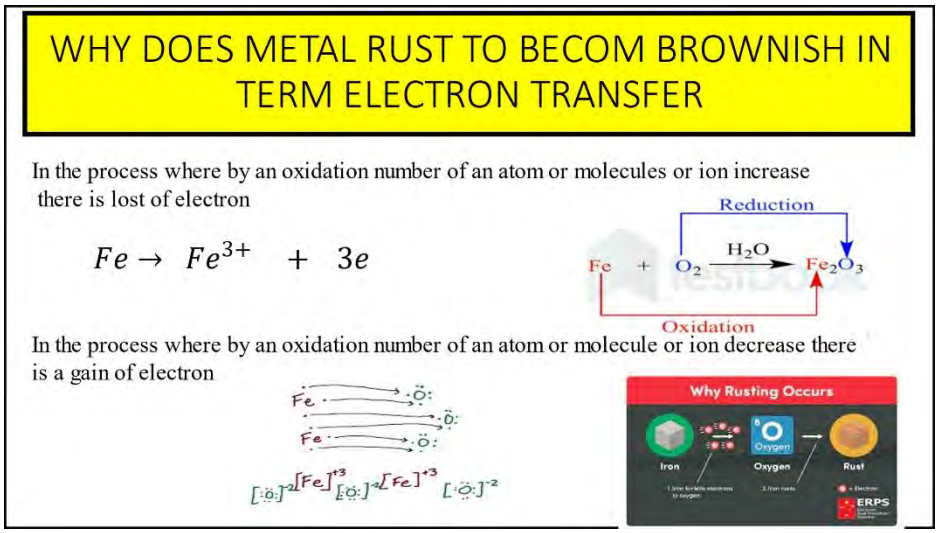


Figure 9.10: Showing the electron transfers

Concluding his explanation of electron transfers between atoms or ions, Madiba used an animation video (referred to as ICT in this thesis) to illustrate and show the learners the movement of electrons. At this point, most learners indicated that they understood and said: "*Iyabonakala kengoku*" (It is clear, or we can see it now). After this video, Madiba summarised what had been taught.

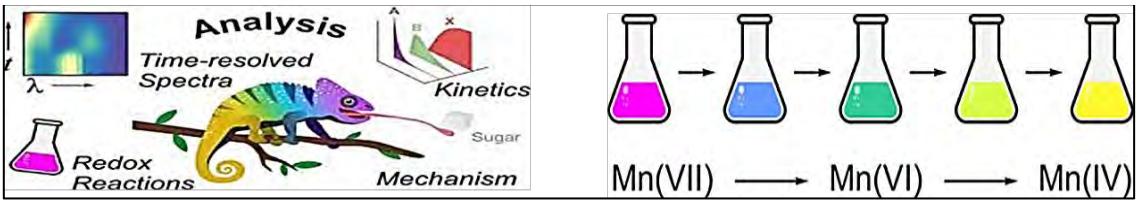


Figure 9.11: Showing the chameleon experiment

In conclusion, Madiba indicated to the learners that he was going to do a practical demonstration to show the colour changes during a chemical reaction commonly known as the 'chameleon experiment' which is a redox reaction as shown in Figure 9.11 above. In this experiment, the colour of the solution changed as the oxidation number of manganese ion (Mn ion) got smaller and smaller as shown in the diagrams above. He used the materials that were placed on his table before the start of the lesson. The procedure was as follows:

> Solution A: Prepare a beaker with 500 ml of water, add 6g of NaOH and 9g of sucrose, then stir.
> Solution B: Prepare the potassium permanganate solution by adding 0,03g of $KMnO_4$ into 30 ml of water.

Then, add solution B to solution A and stir. Watch the changes in colour. Even though we could see some colour changes, Madiba told the learners that the experiment did not work out well; the colour changes did not show as expected. He explained that could be because he did not use NaOH powder or the fact that he did not use distilled water but used tap water instead, so the water probably had its own ions. However, he promised to do the experiment the next day. Then, he thanked the learners and dismissed them. Indeed, Madiba kept his promise. The next day he demonstrated the colour changes of the solution and explained those changes to the amazement of the learners. I could see smiles on the learners' faces and I also heard some of them saying *"Inika umdla kakhulu, kwaye iyacaca kengoku"* (This lesson is very interesting,

and it makes more sense now). Next, I will present my observations of the lesson on waves and sound.

9.4 Summary of the Lesson on the Topic of Waves and Sound

In this section, I discuss the setting of the scene, the introduction of the lesson, the lesson build-up, and the conclusion of the lesson.

> To teach in a culturally relevant way, Chemistry teachers must use a language that allows them to elicit learners' roles that will empower learners to want to do and learn science, this includes ways to engage learners in the knowledge, language, and skills of science formally (in school) and informally (at home) and to make personal connections to science. The goal and content for teaching science must be educationally beneficial such that Chemistry teachers develop and maintain cultural competence for the learners they teach. (Mensah, 2011, p. 301)

9.4.1 Setting the scene

This lesson was taught by MaNgconde, a qualified Physical Sciences teacher with a BEd (science and mathematics methods) from Fort Hare University, a historically Black university with a history of producing several Black political leaders in South Africa, leaders such as Oliver Reginald Tambo (who was the former president of the African National Congress in exile), Nelson Rholihlahla Mandela (the first Black President of South Africa) and others. MaNgconde also had a BEd Honours (Science Education) from Rhodes University, a historically White university. This suggests that she came with a wealth of diverse teaching perspectives and experience. MaNgconde was a learner at Buyelembo Combined and had 10 years of teaching experience at the same school. She was from Bathurst, a small town about 10 km away from Port Alfred. MaNgconde has taught grades 8 and 9 Natural Sciences over the years and Physical Sciences grades 10 to 12 and has produced good results. In other words, she was an experienced teacher.

The lesson was presented to the Grade 10 Physical Sciences class. The class consisted of 13 learners (7 girls and 6 boys). MaNgconde stood in front of the learners next to a desk with some musical instruments. Consistent with Lesson Studies, the PLC members and I were seated at the back behind the learners to watch the co-developed exemplar lesson. One of the teachers videotaped the session. Also present in the class and facing the class was Mnqarhwane, one of the local musicians who was also a gardener at Buyelembo Combined School. Indeed, Mnqarhwane was an IKC especially where African music is concerned.

I noticed that Mnqarhwane had a guitar in his hands. MaNgconde was holding a piece of paper which I later found was her lesson plan and had some notes on the desk. I also noticed that the topic was written on the board, together with the focus of the lesson and the key concepts, namely *pitch*, *frequency* and *amplitude*. Among the musical instruments that were on MaNgconde's desk were different kinds of vuvuzelas, flute, melodica, an instrument made of straw and two metal tins connected by a cotton string. At the back of the class, there were drums and two guitars.

[17]**Figure 9.12: Showing the musical instruments and the learners' interactions**

9.4.2 Lesson introduction

MaNgconde started her lesson by greeting the learners and indicating that the lesson was on the topic of waves and sound. She then introduced the IKC, Mnqarhwane and us and told the learners not to mind us. Then, she said: *"Ndiyayazi besenifundile nge waves ne sound"* (I know I have already taught you the lesson on waves and sound). Thereafter, she recapped with the learners some of the concepts that they already knew. For instance, she explained that a pulse was a single disturbance in a medium and that a succession of pulses formed a wave. Then she asked the learners to mention the two types of waves that they had learned about. The learners were given codes - L1-L13 (Learner 1 to Learner 13). L1 responded and said: *"We have transverse and longitudinal waves, ma'am"*. MaNgconde said: *"That's right"*.

[17] All the participants in this study consented for their photographs to be used in the thesis and requested its copy.

Thereafter, she engaged the learners in a discussion of each of the variables in the equation for the speed of a wave, to which most of the learners responded in unison and said: *"V is the speed of the wave, f is the frequency and lambda (λ) is the wavelength of the wave".* MaNgconde seemed pleased with the response as I noticed a smile on her face. She quickly asked her next question: *"Please define an amplitude".* L2 responded: *"An amplitude is the distance between the rest position or equilibrium and the crest or a trough of a wave".* MaNgconde affirmed the learner's response by saying: *"Very good".*

9.4.3 Lesson build-up

Next, MaNgconde changed gear and introduced the focus sub-topic of the day: "*How are the sound waves produced?"* She pointed to the board and said: *"Today we are interested in finding out how the sound waves are produced, and to get a better understanding, we will use various musical instruments and the assistance of Mnqarhwane"*. She indicated that the learners were going to be given an opportunity to explore how the various musical instruments produced a sound. She also indicated that as the wave travelled it transferred energy. Then she indicated that with the use of easily accessible resources (Asheela et al., 2021) and by tapping into the local knowledge of Mnqarhwane, she hoped that the learners were going to understand how sound was propagated. This resonates with Mensah's (2011) view as pointed out in the quotation above.

Thereafter, she asked the learners to blow on the various musical instruments and compare the sounds produced. L3 tried to blow a vuvuzela to the amusement of the class as she could not produce any sound. L4 tried as well but there was no sound, the entire class burst into laughter. Fortunately, L5 was more skillful and knew how to blow a vuvuzela. She explained to the class the art of blowing into the vuvuzela and how to play a melodica to produce a harmonious sound, and the class cheered her on. This resonates with Stott (2016) that learners can be knowledgeable about others as well. I noticed that there were social interactions among the learners as they were exploring the various musical instruments (Vygotsky, 1978). The learners were laughing, talking and explaining to each other and it seemed that they were enjoying themselves (Lemke, 2001). MaNgconde asked: *"What did you notice as the learners were blowing some instruments and beating up the drums?"* L6 responded and said: *"They produce different sounds ma'am"*. MaNgconde asked a follow-up question and said: *"Why are they producing different sounds?"* The class responded in unison and said: *"Kaloku azifani ma'm"* (meaning, it is because the instruments were different).

MaNgconde asked if there were any other explanations. L6 explained that it also depended on how much you blew because the same instrument could produce different sounds. L5 the skillful one explained that the various musical instruments were made of different materials, for example, the vuvuzela was made of plastic while the drums were made of different materials (Liveve, 2022) and the guitar was made of wood and strings. She further explained that these materials produced different vibrations, hence we could hear different sounds. MaNgconde acknowledged the contributions of the learners and further explained that this also affected the pitch of a sound wave. She then asked if the learners understood the relationship between the sound and the pitch. L7 responded: *"The pitch had something to do with how high or how low the sound was"*. L8 explained that: *"Yes mam, the pitch depends on the frequency of an object"*. L9 added that: *"The sound also depended on the amplitude".* MaNgconde seemed pleased with the learners' responses.

At this point, she drew on the board a wave with a bigger amplitude and on the same diagram a wave with a smaller amplitude. She explained that the wave with a larger amplitude represented a musical instrument that produced a louder sound, and the smaller amplitude represented an instrument with a smaller sound. She then said: "*Ngoku ndizakucela utata uMnqarhwane asidlalele ikatari asele esicacisela kufuneka wenze njani ukuze ingxole naxa ufunana itsholo ezantsi*" (At this stage I will request Elder Mnqarhwane to demonstrate and explain how we produce a high and low pitch using a guitar). Regarding the guitar used in the lesson on sound, the science teacher was looking for an uhadi or inkinge (Xhosa traditional music instruments) similar to Tshitshi's (2024) study that was conducted in South Africa. But she could not get them. She then had to improvise and invite an IKC to play the guitar, which I acknowledge is not a traditional instrument but rather a Western instrument. However, the guitarist played traditional music similar to Liveve's (2022) study that was conducted in Namibia.

Mnqarhwane demonstrated and explained at the same time. Holding his guitar and his finger on the string he said: *"Jongani iminwe yam indawuni, xa uyicenga itsholo ezantsi"* (Look at my fingers; when I press gently it produces a soft pitch) and demonstrated and asked the learners: *"Niyayiva xa ucinezela kancinci, uyicenge ayingxoli ipitch isezantsi"* (Mnqarhwane emphasised and demonstrated how a low pitch was generated).

[18]**Figure 9.13: Showing MaNgconde, Mnqarhwane and Cirha after the lesson**

After this explanation, Mnqarhwane showed the learners how a high pitch was generated; he asked the learners to compare the vibrations of the guitar string when he pressed hard on the string and when he pressed gently. The learners noted the difference saying: "*The vibrations are louder and longer when you press hard, we can see the string"*. L9 said: *"Even when you touch the vibrating string you can feel the difference"*. They gave Mnqarhwane a round of applause, he bowed and smiled. I noticed a beautiful smile on Mnqarhwane's face as he thanked the teacher and the learners.

After the interesting presentation by Mnqarhwane, MaNgconde called two volunteers from the learners to come to the front for the demonstration of the can and string telephone. This is a game that we used to play when growing up, so it brought fond memories to me. I heard other PLC members commenting that they used to play this game as children. Two volunteers came. L1 was holding one end of the telephone and L2 holding the other hand. L1 said something through the can but L2 did not hear. The learners indicated that was because the string was not tight enough for the vibrations to carry the sound to the other end. After tightening the string, L2 could hear clearly. MaNgconde asked a second group of two volunteers to come and do the same thing but this time around she asked the second learner to step outside and leave a gap in the door for the string.

The two learners started their conversation, the one inside the classroom was laughing and said: *"Imnandi legam"* (This game is nice). I observed that the class was interested in the

18 The participants consented for their photographs to be used in the thesis and requested its copy.

conversation as they asked: *"Uthini?"* (What is he saying?). The class in unison agreed that the lesson was fun. This activity was followed by a group discussion. L10 started the discussion when she asked: *"Isebenza njani kanye kanye lefoni?"* (How does this phone work?). L5 responded: *"Yenziwa zivibrations kaloku ezihamba kwintambo ziye kwelinye icala"* (meaning, it is caused by the vibrations through the string). MaNgonde said: *"Yes, the vibrations of the speaker's voice make the end of the can vibrate, the string transmits the vibration along the string to the other can which produces sound waves in the air that the listener can hear"*. L10 said: *"So ifoni yokuqala isuka kulento?"* (This is how the phone was invented?) MaNgconde commented: *"Maybe you are going to invent other things of interest in the near future"*.

Figure 9.14: Showing learners using the can and string telephone and discussions

Concluding the lesson, MaNgconde recapped what had been taught and learned through the discussions. She gave the learners an opportunity to comment on the lesson. Most of the learners commented that they had enjoyed the lesson. L11 said: *"Ibinmandi kakhulu le lesson ma'm"* (meaning this lesson was fun ma'm). L12 indicated: *"Kufuneka sibe ne lessons ezinje mam, simeme nabanye abazali njengo tata uMnqarhwane"* (We should have more lessons like this one and invite other parents like Mnqarhwane). MaNgconde gave the learners the task of working in two groups and making mind maps and concepts based on the concepts that emerged during the lesson. On that note, MaNgconde dismissed the learners and promised to organise other IKCs to assist in other topics.

Next, I present and analyse the data that emerged from the lessons on waves and sound and redox reactions.

9.5 Data Presentation and Analysis

Drawing on the TSPCK analytical framework, I now present and discuss the themes that emerged from the data of the lessons observed. Literature and theory are used to pull the threads together. I employed the key concepts of Vygotsky's SCT (see Section 3.2). Excerpts from the teachers' reflections were also used to give the *voice* of the participants and to paint a picture of what took place during the lesson observations. The point of interest was to see how the mediation process (Vygotsky, 1978) took place during the lessons and how the teachers' ZPD and/or PCK shifted, using a Lesson Study approach. I took a page from Cohen et al. (2018) notebook, who posit that observations can enable the researcher to access interactions in a social context and yield systematic records of those interactions in many forms and contexts and help the researcher to draw conclusions. Here are the themes that emerged from the data of the lessons observed.

9.5.1 Soliciting learners' prior knowledge to enhance learning

The main goal of this study was to explore the use of a Lesson Study approach when working with science teachers in a township school on how to integrate IK to mediate learning on the topics of waves and sound and redox reactions. Thus, it was within the goal of this study that, as espoused by Shulman (1986), the transformation of knowledge on each topic taught was crucial. I observed the science teachers teaching the two topics of interest in this study. In all lessons observed before and after the intervention, both teachers gave clear instructions and explained the objectives of the lesson as indicated in 9.3 and 9.4 above.

To introduce our co-developed lessons both teachers used a question-and-answer method. For instance, Madiba used the illustration of an apple to elicit learners' everyday prior knowledge, encouraging learners to use their daily experiences from home to explain what would happen to the colour of the apple that was bitten and why. On the other hand, MaNgconde asked questions based on the previous lessons on waves and sound. It seems that both teachers viewed eliciting learners' prior knowledge as a critical element of the lesson. I used Mavhunga and Rollnick's (2013) five components of the TSPCK to analyse the data that emerged. In this section, I specifically focus on how the science teachers drew on learners' prior knowledge and how they used it to clarify misconceptions or to strengthen their teaching of the concepts. The two science teachers differed in their levels of engagement with it and with their learners.

In Madiba's case, he encouraged the learners to use their daily experiences from home and link those experiences to what was taught in class to make science relevant and accessible (Nhase, 2019). Madiba used the example of an apple as described earlier. Even the resource (an apple) he used was familiar to the learners' context, thus closing the gap between home and school (Aikenhead & Jegede, 1999; Cronje et al., 2015). Madiba's lesson was characterised by a question-and-answer methodology and reinforcement and clarification of misconceptions (Mavhunga et al., 2016). I observed that Madiba seemed comfortable with the subject content and the lesson was flowing nicely. It seemed that the learners were enjoying the lesson as I noticed that they were focused and occasionally commented that the lesson made sense and had smiles on their faces.

MaMhegeba said: *"Prior knowledge of the learners was core in the lesson. Learners were not told; they could see for themselves, understand, make their own conclusions, teach others".* This resonates with MaMyeka's view:

> *The teacher bit an apple and left it for a while carrying on with his lesson, then engaged the learners by asking them what they saw happening to the apple; the learners explained that the bitten part was turning brown, then he gave them a concept for the change in colour,* ***oxidation.*** *I found this approach most fascinating.*

It seems Madiba's approach had a profound impact on the teachers as well. MaMpehle said: *"To tell the truth I did not include indigenous knowledge at all but I have seen when Madiba was teaching the learners were focused, just from using an apple and learners' knowledge, and that makes science easy to understand"*. These comments reveal that solicitation of learners' everyday prior knowledge is essential for effective teaching and learning of science (Aikenhead & Jegede, 1996; Seehawer, 2018).

Contrary to Madiba's approach, MaNgconde's question-and-answer approach was based on what the learners were taught in the previous lessons. This is in line with Mavhunga and Rollnick's (2013) understanding of prior knowledge. This understanding of prior knowledge tends to emphasise the knowledge that learners bring to a learning situation from their previous formal learning experiences and grades. My criticism of this use of prior knowledge is that it tends to alienate the knowledge that the learners bring from home (Erinosho, 2013; Jegede, 1999) and that leads to what Le Grange (2007) refers to as cognitive dissonance (see section 1.3). For that reason, Roschelle (1995) warned that neglecting prior knowledge can result in

the learners learning something contrary to the teachers' intentions which is probably what is happening in many township schools.

However, scholars such as Taylor (1999) argue that not all prior knowledge is educational. This suggests that any misconceptions embedded in learners' prior knowledge need to be cleared up and corrected. I concur with Mukwambo et al.'s (2014) view that learners come to school with funds of IK from home which are useful in science classrooms. It is recognised also that prior knowledge could be in the form of IK (Hashondili, 2020).

In this study, prior knowledge refers to both the knowledge that learners acquired from their previous grades and their everyday experiences at home. During her question-and-answer session, MaNgconde recapped with the learners some of the concepts that they already knew. I particularly enjoyed the part of the introduction when she engaged the learners in discussing each of the variables in the equation for the speed of a wave, to which most of the learners responded in unison and said: *"v is the speed of the wave, f is the frequency and lambda (λ) is the wavelength of the wave".* As indicated in section (2.2), life is about relationships and science learners should, therefore, know and understand those relationships for meaningful learning to take place. Mirrored against her previous lesson on waves and sound before the intervention, MaNgconde seemed more relaxed and confident.

This observation was picked up by MaMyeka who said: *"I think our interaction as a team and document analysis has certainly changed MaNgconde, because during the first lesson she was panicking and had very little engagement with the learners"*. Concurring, MaMhegeba said: *"I like the fact that she asked more questions and get the learners to talk, she looks more relaxed in this lesson".*

However, there were missed opportunities during the question-and-answer session. For instance, when MaNgconde asked the learners to mention the two types of waves that they had learned about and they responded and said transverse and longitudinal waves, she should have asked the learners to draw those waves on the board and/or describe those waves, to reinforce concepts like amplitude, wavelength and points in/out of phase by using visualisation and illustration for developing learners' ZPD (Vygotsky, 1978). In my view, such an approach could have allowed learners to interpret their understanding and perhaps promote discussion amongst learners (Agunbaide, 2021; Mutanho, 2021; Vygotsky, 1978). The missed opportunities in Madiba's and MaNgconde's lessons were pointed out during our stimulated

recall discussions to strengthen the teachers' PCK, a phenomenon which is in line with Lesson Studies. Data revealed that the teachers' PCK had improved in this area, that is the solicitation of learners' prior knowledge.

9.5.2 Promoting interest and active participation

Analysis of the data generated from the post-intervention lessons revealed that the science teachers supported the integration of IK in science lessons and that they promoted the interest and active participation of the learners. Most of the learners commented that the lessons were interesting (some learners indicated that they had fun) and that they understood what was taught in class. For instance, when Madiba asked his learners if they could explain their observations, one learner responded and said that: "*I see that the part of the apple that was eaten changed colour to brownish and that is because that part is exposed to air, so the apple reacted with oxygen"*. Interestingly, the class applauded him, and I heard one learner saying: *"Hayi uyibambile mntakwethu"* (meaning, you got it my brother). Even though Madiba missed the opportunity to elaborate further, it must be indicated that the learners clearly had fun and were actively engaged during the lesson. To Sedlacek and Sedova (2017) learners' learning is akin to a process of active participation.

Similarly, in MaNgconde's class, the learners were laughing, talking and explaining to each other (Ngcoza & Southwood, 2015) and it seemed that they were enjoying themselves. They even gave Mnqarhwane a round of applause as mentioned above. Commenting about the lesson, one learner from MaNgconde's class said: *"Ibinmandi kakhulu le lesson mam"* (meaning this lesson was fun, mam). I observed that the use of isiXhosa (where IK is embedded) as a cultural tool by MaNgconde to mediate learning of the topic of waves and sound seemed to be a strategic pedagogical move. It was encouraging to see such active engagement and learners talking freely in class (Lemke, 2001). Similarly, when Madiba used IK-related examples and practices to engage learners the participation of learners increased. To me that indicated that transformative learning was taking place (Chilisa, 2012; Mertens, 2010).

The picture painted by the above comments and learner gestures suggests that the integration of IK in science lessons motivates learners and makes learning more meaningful. Kuhlane (2011) suggested that science taught in school should be meaningful and should take into consideration what the learners already know from their homes or communities. During the stimulated recall discussions after the lessons, the other science teachers seemed to concur with

my observations. This was evident during our stimulated recall discussions. MaMhegeba said: "*Madiba's lesson was interesting, and the approach was communicative; learners were involved"*. And further said: "*Learners were not told, they could see for themselves, understand, make their own conclusions, teach others"*. MaMyeka said: *"Observing this lesson was of great interest to me"* and continued: *"I observed that learners were interested in what the teacher was saying, there was silence and participation when needed"*. MaMpehle said: *"For me the lesson was very interesting; it was presented with confidence, and I saw that the learners enjoyed the lesson, and it was clear to me that they understood the teacher"*. Madiba said: *"The way the learners were contributing during the lesson was so profound and I like the fact that they appreciated Mnqarhwane's contribution; it was a nice lesson I also learned one or two things from it"*.

An analysis of the above comments by the teachers reveals that teaching from the known to the unknown promoted interest and active participation. One could argue that the teachers' curriculum salience was evident based on how the lessons were presented (Shinana, 2019). To this effect, scholars like Ogunniyi (2007a) and Le Grange (2007) concluded that the integration of IK in science lessons demystifies science which many learners view as very abstract and difficult. In that regard, it seems that the use of a Lesson Study approach had paid dividends.

9.5.3 Promoting conceptual understanding

As explained in section (3.3), Mavhunga and Rollnick's (2013) five content-specific components of the TSPCK were used as a lens to analyse the data that emerged from the science lessons observed. I wanted to see whether the intervention had shifted the teachers' understanding of how to integrate IK into science lessons. It is acknowledged in this study that different PCKs are observed among teachers (Calson & Daehler, 2019).

Drawing on the seminal work of Mavhunga and Rollnick (2013), I focused on the five components of the TSPCK to scrutinise the data that emerged, namely: *learners' prior knowledge*; *curriculum salience; what is difficult to understand; representations;* and *conceptual teaching strategies.* I noticed that the two science teachers were at different levels or ZPD. For instance, Madiba demonstrated a good understanding of curriculum salience in that he seemed clear about the knowledge of concepts that make up the topic on redox reactions and the relationship between them. For example, to help the learners understand the terms *oxidation* and *reduction*, building on the learners' prior everyday knowledge and storytelling

Madiba explained the two concepts in terms of oxygen transfer, using a simple equation. After laying this solid foundation he made sure that the learners understood these two concepts in terms of oxygen transfer (see box 9.5 above) and then moved on to explain the two concepts in terms of electron transfer which was a bit difficult for the learners to understand. He used an equation to illustrate his point: $Fe \rightarrow Fe^{3+} + 3e^{-}$. After writing this equation Madiba said:

> *This time around we are going to try to explain the terms oxidation and reduction in terms of the transfer of electrons. Maybe you have a question, what electrons have to do with oxidation and reduction, don't worry that's what you are about to discover.*

As stated in 9.3 (Summary of the lesson on redox reactions) I noticed from the learners' facial expressions that they seemed interested and were paying attention. To bring more clarity for the learners, Madiba illustrated to the learners what happens when electrons are transferred using the Lewis diagrams which are taught in grade 10, what Mavhunga and Rollnick (2013) refer to as *representations*. *Representations* could be illustrations, metaphors, demonstrations, experiments, analogies, models or simulations/animations. This refers to how learning content is presented in such a way that it carries meaning to the learners for conceptual understanding.

Data showed that this was Madiba's strong point and a noticeable shift in his PCK in terms of IK integration into science lessons. Sharing similar sentiments were the science teachers during our stimulated recall discussions:

> *A more simplified lesson beginning from simple to more demanding in knowledge; I have learned a lot (MaMhegeba).*

> *I was pleased to see how the lesson progressed where the teachers moved from easy to understand - e. g. using the reaction with oxygen - before going to the difficult explanation of electron transfer to explain oxidation and reduction reactions.* (MaNgconde)

> *More interesting also … Madiba used different teaching methods which catered for all IQ levels of learners; methods like e-Learning, practical investigation, equations, stories… it was easy to follow his lesson.* (MaMyeka)

> *The teachers started by a simple explanation of oxidation using examples that we all see every day before moving to difficult explanation of electrons and equations; this was easy to follow even though the transfer of electrons was a little difficult. I got it when he used the video. It was a good lesson.* (Zizi)

> *I observed that the integration of IK during the lesson kept the learners interested and they were following what they were taught and I liked the teacher's approach of using storytelling and videos.* (MaMpehle)

All five science teachers agreed that Madiba's lesson promoted conceptual understanding for the learners. To emphasise his point and to accommodate learners with learning difficulties Madiba used an animation video as a teaching aid to help the learners visualise the process of electron transfer. According to Nicodemus (2017), practical activities and visualisation make science lessons interesting, improve the learners' attitudes to science and promote a deeper understanding of science concepts. In this regard, most learners in Madiba's class indicated that they understood and said: "*Iyabonakala kengoku*" (It is clear, or we can see it now).

The integration of IK and the use of easily available resources for illustration in Madiba's science lesson produced positive results in terms of assisting the learners to understand the science concepts. This was evident when he explained concepts like *oxidation numbers, oxidising agent* and *reducing agent*, which the learners seemed to grasp. For instance, as indicated above Madiba used the equation, $Fe(s) + O_2(g) \rightarrow Fe_2O_3(s)$ and asked some questions and the learners responded well to those questions. These are some of the concepts the Examiners Reports highlighted as one of challenging concepts for the learners (DBE, 2017–2021) (see Section 1.2) in the chemistry Paper 2, final examinations.

After the video, Madiba pulled all the treads together and summarised what had been taught. I observed that the learners seemed happy and most of them commented that they understood. It is worth noting that Madiba concluded his lesson with a hands-on practical experiment, the 'chameleon experiment', which is a redox reaction as shown in Figure 9.4 above. The aim of the practical demonstration was to emphasise the concept of *oxidation numbers* and to show in practice that the colour of the solution changed as the oxidation number of manganese ions (Mn ion) got smaller and smaller in the experiment. This was used as a *conceptual teaching strategy,* and it worked.

The study revealed that there was a remarkable shift in Madiba's PCK in terms of IK integration. In this regard, the intervention shifted the teachers' understanding of how to integrate IK into science lessons. Secondly, both the use of easily accessible resources and hands-on practical activities seemed to have empowered Madiba, as observed in his teaching approach after the intervention.

Likewise, MaNgconde's lesson on waves and sound also revealed some interesting findings. For instance, unlike during the pre-intervention lesson, MaNgconde seemed composed and calm. This observation is based on her voice projection and the confidence she displayed when she introduced her lesson with a smile on her face. For example, MaNgconde said: *"Today we are interested in finding out how the sound waves are produced, and to get a better understanding, we will use various musical instruments and the assistance of Mnqarhwane"*. To me, this statement demonstrated that MaNgconde was clear about the main aim of the lesson and also showed that she wanted to take her learners along. During the pre-intervention lesson, she seemed tense. It could be argued that her involvement during the document analysis and the co-development of the exemplar lesson could have contributed to an increase in her confidence level.

Secondly, in terms of curriculum salience MaNgconde demonstrated that she had a fairly good understanding of the concepts related to the production of sound. However, my criticism is that she could have created space for the learners to discuss the concepts related to the generation of sound before asking the learners to explore the musical instruments. Be that as it may, the use of easily accessible resources was quite an innovation on its own. This time around MaNgconde engaged the learners more, for instance, she asked questions such as: *"What did you notice as the learners were blowing some instruments and beating up the drums?"* and *"Why are they producing different sounds?"*

MaNgconde used a question-and-answer approach and isiXhosa (local language) to promote conceptual understanding. A bank of IK is embedded in the local language and I observed that giving the learners freedom to speak isiXhosa allowed the learners to cross cultural boundaries and assisted in linking the Western concepts and local concepts. Additionally, she used the more knowledgeable learners (Vygotsky, 1978) to assist her during the lesson and I found that commendable. Furthermore, the involvement of the IKC (Mnqarhwane) in demonstrating to the learners how the high and low pitch were produced when playing a guitar served as a very good illustration and was a strategic move. Mnqarhwane demonstrated and explained at the same time as explained above. For instance, holding his guitar and his figures on the string he said: *"Jongani iminwe yam indawuni, xa uyicenga itsholo ezantsi"* (Look at my fingers; when I press gently it produces a soft pitch) and demonstrated and asked the learners: *"Niyayiva xa ucinezela kancinci, uyicenge ayingxoli ipitch isezantsi"* (Mnqarhwane emphasised and demonstrated how a low pitch is generated).

observed that the learners seemed to enjoy Mqarhwane's practical demonstration and seemed to have gained a lot from him. The following responses to some of MaNgconde's questions by the learners demonstrated conceptual understanding after Mnqarhwane's presentation. L1 responded and said: *"The pitch had something to do with how high or how low the sound was"*." L8 explained that: *"Yes ma'am, the pitch depends on the frequency of an object"*. L9 added: *"The sound also depended on the amplitude"*.

Moreover, the involvement of Mnqarhwane who is considered to be 'uneducated' and still managed to help the grade 10 learners learn science concepts contributes to new knowledge. It was interesting to hear some learners requesting Mnqarhwane to teach them how to play the instruments after school and was more pleasing to hear Mnqarhwane agreeing. Mnqarhwane seemed to enjoy himself as he was all smiles, and that speaks to mutual benefit. Reflecting on MaNgcode's post-intervention lesson, the science teachers had interesting things to say during our stimulated recall discussions. MaMpehle said: *"Okokuqala ibinika umdla kakhulu le lesson kaMaNgconde ndiyithandile. Okwesibini indlela abasebenzise ngayo abantwana notata uMnqarhwane ndiyithandile kwaye ndifunde likhulu mna"*. (Firstly, the lesson by MaNgconde was very interesting, I enjoyed it. Secondly, I liked the way she engaged the learners and Mnqarhwane and I have learned a lot from it). Madiba said:

> *The lesson was great; you could see that MaNgconde was enjoying herself as she was presenting the lesson and we could see that the learners were enjoying the lesson as well … Mnqarhwane brought his IK; he is very good … the learners like him, I say the school must use people like him more.*

MaMhegeba said: "*I liked the fact that MaNgconde used easily accessible resources and the learners … that was very good. Hayke andifuni kuthetha uyabona uMnqarhwane uyayenza into yakhe labhuti"* (I don't want to say much, Mnqarhwane is just good, he knows his stuff). Zizi said: *"She did well, and I believe that she is going to be one of the best science teachers if she continues to teach like that*". MaMyeka said: *"As MaNgconde was teaching I could see the importance of having a PLC; ibingathi ngomnye umntu lobetitsha namhlanje, nam nditshintshile indlela endizibonangayo izinto*" (It was as if MaNgconde was a different person today, I also have changed the way I perceive things). *"Xa sifika kuMqarhwane kuyabonakala ukubaluleka kolwazi lwemveli nolwimi lwethu, ndiyithandile kakhulu le lesson yanamhlanje"* (When I talk about Mnqarhwane I see the importance of IK; I thoroughly enjoyed today's lesson). These comments point to a remarkable improvement that was noticed by our PLC of MaNgconde's PCK in terms of IK integration into science teaching.

9.6 Chapter Summary

This chapter analysed, interpreted and discussed the data that emerged from co-developed exemplar lessons, lesson presentations, and stimulated recall discussions that were conducted after the lessons.

The findings in this study revealed the importance of the intervention workshops and the co-development of exemplar lessons and how they positively influenced the teachers' ZPD and PCK. The study also highlighted the importance of tapping into the cultural bank of IKCs and the unique contribution of the IKCs and new knowledge in this study. Data showed the relevance of integrating IK as it improved the critical thinking capacity of the learners and helped improve their conceptual understanding.

It was found that the solicitation of learners' prior knowledge and the use of isiXhosa promoted interest and active engagement by the learners and assisted in crossing cultural boundaries, linking Western concepts to local concepts. The findings of this study revealed that easily accessible resources and practical activities enhance learning and serve as effective conceptual teaching strategies.

CHAPTER TEN: SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSIONS

> It galls us that Western researchers and intellectuals can assume to know all that it is possible to know of us, on the basis of their brief encounters with some of us. It appals us that the West can desire, extract and claim ownership of our ways of knowing, our imagery, the things we create and produce and then simultaneously reject the people who created and developed those ideas and seek to deny them further opportunities to be creators of their own culture and own nations. It angers us when practices linked to the last century, and the centuries before that, are still employed to deny the validity of Indigenous peoples' claim to existence, to land and territories, to the right to self-determination, to the survival of our languages and forms of cultural knowledge, to our natural resources and systems for living within our environment. (Smith, 2012, p. 1)

10.1 Introduction

This chapter gives a brief synthesis of the study by providing key findings. It comprises major findings that emerged from chapters five to nine. It starts with an overview of the whole research process. This is followed by the summary of the key findings of the study, guided by the research questions, the new knowledge that emerged from the research, the conclusion to the study and the recommendations. Lastly, the chapter discusses the limitations of this study and provides suggestions on areas for further research, and my personal reflections on the research journey.

10.2 An Overview of the Study

This study was conducted in a township school in South Africa. Taking counsel from Smith (2012) as pointed out in the epigraph above, the main goal of this study was to leverage the use of a Lesson Study approach when working *with* science teachers on how to integrate IK to mediate learning of the topics of waves and sound and redox reactions in a township school. Essentially, the study was conducted at a time when it was observed that there was a decline in the number of learners choosing to do Physical Sciences in Grade 10 in South Africa, particularly in township schools. Moreover, the study was conducted at a time when most of the township learners performed poorly in mathematics and science (Reddy et al., 2020),

particularly in the Eastern Cape. This conundrum has led some scholars such as Klein (2011), Mutanho (2021) and Seehawer (2021) to call for alternative approaches to make science accessible and relevant to learners. I subscribe to this school of thought and belief that similar to the former model C schools and independent schools, township schools also have the potential to be schools of excellence.

It is against this backdrop that this study sought to contribute towards the capacity building of science teachers by addressing and hopefully overcoming the challenges that they experienced in their teaching practice with the integration of IK into science lessons. This was done using a Lesson Study approach through our PLC where teachers were allowed to work collaboratively with the community elders, the IKCs. In addition, this was achieved through document analysis and the co-development and enactment of exemplar lessons. Thus, the purpose was to emancipate the teachers from their Westernised ways of thinking (Mutanho, 2021) and transform their teaching practices. To achieve this goal, the following research questions were addressed:

1. What are the science teachers' perspectives, pedagogical insights, and practices regarding integrating Indigenous Knowledge in science teaching?

    (a) What are science teachers' perspectives and pedagogical insights regarding integrating Indigenous Knowledge into their teaching before the intervention?
    (b) What are science teachers' classroom teaching practices before the intervention?
2. What learning opportunities are created for the science teachers through capacity-building workshops by critical friends before the intervention?
3. What learning opportunities are created (or not) during the presentations by the Indigenous Knowledge Custodians?
4. What learning opportunities are created (or not) during hands-on practical activities on 'kitchen chemistry'?
5. How do science teachers co-develop and then enact their exemplar lessons that integrate Indigenous Knowledge into the topics of waves and sound and redox reactions?

To address these research questions, the study followed six phases during the data generation process. The first phase was the focus group discussions (sharing circles) and observations of two lessons prior to the intervention; the second phase consisted of pre-intervention capacity-

building workshops; the third phase consisted of participatory observations and journal reflections; the fourth phase was the group reflections (workshop discussions and journal reflections); the fifth phase was the lesson observations (videotaped lessons), stimulated recall interviews and journal reflections; and the sixth phase was the participatory observation and journal reflections. Similarly to Nhase's (2019) study, each phase was followed by a reflective space. Data sets that emerged from each of these phases were then analysed using concepts from the SCT, PCK, and the five components of the TSPCK and the CAT.

10.3 Summary of The Findings

In this section, I present the key findings that emerged from different phases of this study. As alluded to earlier, the findings are presented to my research questions.

10.3.1 Findings related to research question 1

In phase 1, focus group discussions, in the form of sharing circles and two pre-intervention lesson observations were used to gather the baseline or mirror data (Engeström, 2001) before the intervention took place. The findings revealed that the six science teachers who participated in this study were at different levels in terms of their views and understanding of the integration of Indigenous Knowledge (IK) into science lessons. Further analysis of the data showed that the science teachers who participated in this study seemed to understand the benefits of integrating IK into science lessons but lacked the pedagogical content knowledge (PCK) to integrate it.

Also, during the reflection discussions these science teachers indicated that the Department of Basic Education (DBE) did not provide them with the necessary training to help them understand how to integrate IK. Thus, a gap between the intentions of the curriculum, the integration of IK into science to make science accessible and relevant to all learners (DBE, 2011), and the implementation of the curriculum was confirmed. Resultantly, the science teachers were eager and willing to establish their professional learning community (PLC) in cooperation with the Indigenous Knowledge Custodians (IKCs). Such a finding pointed to the importance of capacity-building workshops and the relevance of this study.

10.3.2 Findings related to research question 2

Phase 2 was characterised by a series of pre-intervention workshops as presented in Chapter 6, of which the main aim was to equip the science teachers with the knowledge, skills, and support they might need (Guskey, 1994) to be able to integrate IK into science lessons. Evidence shows that phase 2 created multiple learning opportunities for the science teachers participating in this study. For instance, the study showed that through the capacity-building workshops, the teachers were able to co-construct meaningful solutions that would help them improve their teaching. It was evident that the teachers enjoyed working in a non-threatening environment as I observed that they freely asked questions, argued, and debated with each other until they reached a consensus. Ogunniyi (2007a) refers to this as the equipollent stage in the Contiguity Argumentative Theory (CAT). This finding challenges the top-down approach that is implemented by the DBE in South Africa, where workshops are imposed from above with very little input from the teachers.

The findings of this study further showed that the workshop on journal reflections created an opportunity for the teachers to shift their zone of proximal development (ZPD) (Vygotsky, 1978) in terms of how the reflective journals worked. The general feeling of the teachers after the workshop was that they learned a lot from the learners, and they seemed more comfortable with reflective journals. I submit this as a unique contribution to my study, where teachers learned from the learners. To back up my claim, MaMpehle indicated:

> *The challenge I had before watching the video, I did not know how to start my reflective journal, but the videos made it easy for me, in terms of sharing my thoughts, insights, feelings, emotions and ideas, so I was able to start.*

The presentation on document analysis and co-analysis of curriculum documents marked the end of this phase of the research process of this study. The findings revealed that the teachers gained new insights on how to unpack the curriculum using Mavhunga and Rollnick's (2013) TSPCK components as an analytical lens. They also learned how to support one another and learn from each other's expertise and experience (Feiman-Nemser, 2001).

Also, the findings of this study showed that the science teachers were enabled to understand how to integrate IK into science lessons during document analysis. Attesting to this were the following comments. MaNgconde said that *"I have found out that the textbooks do not accommodate the IK, there are few of them that have examples that include IK".* Similarly, Zizi

said: *"I have learned that our textbooks are not integrating Indigenous knowledge with science".* Notably, this was an important realisation since both teachers showed little or no understanding of how IK could be integrated into science lessons before the intervention.

10.3.3 Findings related to research question 3

In phase 3, participatory observations and journal reflections were employed to explore if learning opportunities were created (or not) during the presentations by four Indigenous Knowledge Custodians (IKCs). The aim was to assist the participating science teachers to become cultural knowledge brokers (Wyatt et al., 2017) as explained in Section 7.1 of this study. In this phase, we invited IKCs to share their knowledge and experiences on cultural beliefs and traditions related to the sea and how to make *isonka samanzi* (homemade bread).

The findings revealed that the science teachers' understanding of how to handle learners with spirit improved after the presentation by Umhlekasi (a traditional healer). This finding resonates with the two-eyed-seeing scholars' point of view that there are multiple realities embedded in IK (Hatcher et al., 2009; Onwu & Mufundirwa, 2020). On the other hand, Dein et al. (2010) posit that it is difficult to comprehend spiritual things. Using CAT provided me with the epistemological landscape of this study to examine the contradictions that surfaced during the presentations by the IKC (Ogunniyi, 2007a) and during the reflections. For instance, I used the CAT to harmonise the tensions between Unhlekazi and the science teachers' Western ways of thinking and training. The study makes a call that IKCs should be invited to schools because they are indeed the custodians of IK (Smith, 2012) and they could help teachers to become cultural knowledge brokers (Wyatt et al., 2017).

The study further revealed that the science teachers' ZPD and PCK shifted positively in this interventionist study during the presentation by Majeke and MaMtshawe at the sea. Essentially, tapping into the cultural heritage of IKCs was one of the foci of this study as an attempt to help contextualise WS as reiterated by Mhakure and Otulaja (2017). For instance, the study showed that science teachers acquired new knowledge, such as the use of language and *storytelling* as mediational tools to promote learning. To Vygotsky (1978), learning and cognitive development are culturally and socially based. Thus, the language barrier was broken down and that encouraged everyone to speak freely without being limited by a foreign language.

10.3.4 Findings related to research question 4

To answer research question 4, phase 4 followed. This was a reflective space wherein our PLC reflected on the practical demonstrations and explanations received from the IKCs and our critical friend.

The science teachers were engaged in two practical demonstrations of kitchen chemistry. The first practical demonstration was conducted by MaMcirha, an IKC who demonstrated how to make *isonka samanzi* (homemade bread) using Indigenous methods. The second hands-on practical activities were conducted by Nozinga, a critical friend from Rhodes University who demonstrated how to do a basic practical activity on redox reactions and practical activities using easily accessible resources (Asheela et al., 2021; Shinana et al., 2021).

Firstly, the study showed that learning affordances were co-created during the presentations by MaMcirha and Nozinga and that learning opportunities were co-created during both hands-on practical activities. This resonates with Asheela et al. (2021) who argue that minds-on, hands-on and words-on approaches enable understanding of scientific concepts. Secondly, the findings of this study revealed that science was contextualised, resulting in greater conceptual learning and hence sense-making of the key scientific concepts developed. Woodley (2009) also sees practical activities as a bridge between what learners can see and do and the scientific concepts that emerge.

However, there were findings unique to each presentation. For instance, the study showed that MaMcirha's practical demonstration afforded the science teachers learning opportunities on how to use IK other science topics. For example, Madiba stated: *"I have learned a better approach to explain Le Chatelier's Principle and rates of chemical reactions and I could use IK in other topics, I just need to research and prepare".* For instance, Le Chatelier's Principle states that if a dynamic equilibrium is disturbed by changing conditions, the position of equilibrium shifts to counteract the change to reestablish equilibrium. In a similar vein, MaNgconde said: *"I have seen how IK was used during the demonstration, I have learned how to use IK in science, and I will try and integrate IK in other science topics, it helps to explain difficult science concepts".* Interestingly, MaNgconde was one of the teachers who demonstrated little understanding of how to link IK and WS, so it could be argued that her understanding of IK integration into science had shifted positively after the intervention.

I found these comments fascinating because two of the interview questions during the sharing circles (see Section 5.2.3) before the intervention were: *Could you please give me an example of any topic in which you think you can integrate local knowledge? Could you please tell me what the advantages are of integrating local knowledge in science lessons?* I observed that there was a vast improvement in science teachers' understanding in terms of the link between IK and WS. Indeed, this interventionist study enabled the IKC and the science teachers to work in harmony as a family (Chilisa, 2012) and transformative learning took place as revealed in the above comments.

Furthermore, the study revealed that hands-on practical activities on kitchen chemistry by Nozinga helped the science teachers gain a better understanding that the use of easily accessible practical activities stimulates excitement and promotes learning. For example, MaNgconde indicated: *"I have learned that doing science in the kitchen can be enjoyable and that learners can go home and explain to their mothers the science concepts, for example when they do umqombothi (African beer)"*. This resonates with Ngcoza et al.'s (2016) conclusion that learners who participate in interesting hands-on practical activities become more motivated to study science at school. I argue that the use of hands-on practical activities could help reduce the decline in the number of learners choosing to do science in Grade 10 in South Africa.

10.3.5 Findings related to research question 5

In the fifth and sixth phases, data that emerged from co-developed exemplar lessons, lesson presentations, and stimulated recall discussions that were conducted after the lessons were used to answer research question 5 of this study. This research question explored how science teachers co-developed and then enacted the exemplar lessons that integrated IK into the topics of waves and sound and redox reactions.

The findings of the study revealed that each group successfully managed to co-develop its exemplar lesson plan and presented it to the entire PLC for comments or suggestions for further improvement. This is in line with the Lesson Study approach as it involves a cyclical process of lesson planning, collaboration, and reflection (Adler, 2017). It was noted that the lesson plans seemed to suggest that the learners would be engaged throughout the lessons. The two science teachers who taught the pre-intervention lessons volunteered to teach these lessons again. It was observed that the two science teachers were able to internalise the exemplar

lessons co-developed in our PLC and then use them during their respective lesson presentations.

The findings from lesson observations revealed that to introduce our co-developed lessons both teachers used a question-and-answer method. Also, both teachers seemed to be mindful of soliciting learners' prior knowledge as a critical element of the lesson. For instance, we observed that Madiba encouraged his learners to use their daily experiences from home (Ogunniyi & Ogawa, 2008) and he subsequently linked those experiences to what was taught in class to make science relevant and accessible (Asheela et al., 2021).

Unlike Madiba, however, MaNgconde asked questions based on the previous lessons on waves and sound, something which was, in hindsight, in line with Mavhunga and Rollnick's (2013) understanding of prior knowledge. Nonetheless, MaNgconde should be applauded for nicely recapping. It was evident from her confidence level that the intervention had a positive impact on her development of PCK. For instance, during our stimulated recall discussions, MaMhegeba pointed this out when she said: *"I like the fact that she asked more questions and got the learners to talk, she looks more relaxed in this lesson"*. The study revealed that both teachers' PCK had improved in the solicitation of learners' prior knowledge and other components of TSPCK. However, there were missed opportunities in both lessons which were pointed out during our stimulated recall discussions to strengthen the teachers' PCK, a phenomenon which is in line with the Lesson Study approach (Alshwaikh & Adler, 2017).

The findings of the study also showed that the integration of IK into science lessons promoted interest and active participation of the learners. To Sedlacek and Sedova (2017), learners' learning is akin to a process of active participation. Thus, the study revealed that the integration of IK by the teachers improved and that they were familiar with the relevant knowledge to enhance the teaching and learning of science. For instance, Madiba used an apple as an easily accessible resource, something that was familiar to the learners' contexts, thus helping the learners with border crossing from home to school science (Aikenhead & Jegede, 1999; Cronje et al., 2015).

Furthermore, the study also revealed that having stimulated recall discussions after each session gave the participants in this study a reflective space to discuss and learn from each other. Thus, the study confirmed that document analysis and co-development of exemplar lessons were

needed to empower the science teachers on the integration of IK during science lessons and to produce the much-needed IK-grounded teaching resources.

10.4 New Knowledge in the Study

The first contribution to new knowledge in this study lies in its focus, which was to work with and support science teachers in integrating Indigenous Knowledge into their teaching.

Informed by its focus, the unique contribution to new knowledge was the invitation of Indigenous Knowledge Custodians (IKCs) to the school premises, to share their cultural heritage about the sea and how to make *isonka samanzi* (homemade bread). Additionally, these science teachers were taken to the sea (out-of-school context) to learn about its cultural heritage from the IKCs (see Figure 7.2).

What makes this new knowledge is that although many studies have been conducted on how to integrate IK into science education, not much research has been done on how to tap into the cultural heritage of IKCs. Furthermore, it is rare to find a study that recognises community elders as MKOs (Vygotsky, 1978) who can contribute their expertise to science education, let alone teach science teachers. Often, IKCs are left out of the education of their children and out of the IK-WS debate, yet they are the custodians of IK. It could be argued that the study's contribution to new knowledge was to break down the cultural boundaries between the community and the school (Michie et al., 2021).

The study's second contribution to new knowledge is that it created an empowering and emancipatory environment for the participating teachers. That is, instead of blaming and pathologising teachers for their lack of PCK to integrate IK into science teaching, through capacity-building workshops, the teachers were empowered on how to integrate IK into their science teaching. This contribution is significant, as many studies have shown that most science teachers seem to struggle to integrate IK into their teaching (Ogunniyi, 2007; Mothwa, 2011; Shizha, 2007). Evidence shows that the capacity-building workshops allowed the science teachers to reflect on their experiences and share ideas during the entire research process. This contributes to new knowledge as the science teachers were afforded an opportunity to analyse the curriculum and co-develop exemplar lessons that integrated IK and present those lessons. In other words, the study gave *agency* to the teachers. Thus, this study demonstrated how continuing professional development (CPD) programmes informed by teachers' learning needs can be conducted.

Thirdly, this research contributes to teacher capacity building and professional growth on how to use reflective journals, which in turn will help science teachers to improve their teaching pedagogy. This was achieved through a workshop using learner videos as a resource. Drawing from the mirror data from the first phase of the study, the study supported and capacitated the science teachers on how to use reflective journals. We all watched the videos of my former grade 10 learners (see Section 4.6.2.2). Therefore, in this study, learners' videos were used as double stimulation for the teachers to highlight the importance of reflective journals. The study showed that the teachers participating in this study learned from the learners which is a rare occurrence because, traditionally in township schools, it is expected that learners learn from the teachers and not the other way around.

Another contribution to new knowledge from this study is that it promoted reflective practice. The general comment from the teachers was that they learned a lot from the learners and were now more comfortable with reflective journaling.

This study challenged conventionally accepted research procedures and showed that, in some instances, they are perceived as unethical by Indigenous people if they are not carefully implemented. I submit this as the fourth contribution to new knowledge of this study. For instance, the study showed that when requesting written consent from the Indigenous participants one should carefully explain the rationale of the request otherwise one could end up offending the participants. Also, the statement that says: "You can withdraw anytime you wish to do so" (*Ungayeka nanini ufuna*) is viewed by African people as if you do not care whether they continue in their study or not. Statements like these, even though they have good intentions as perceived by Eurocentric approaches to research, could result in a novice indigenous researcher not having participants at all when working *with* African people. Thus, the study recommends the Ubuntu perspective as an alternative approach to conducting research with indigenous people.

Last, but certainly not least, the findings in this study revealed the importance of the intervention workshops, the use of easily accessible hands-on practical activities and the co-development of exemplar lessons. The study showed how these positively influenced the teachers' ZPD and PCK. Moreover, the study revealed that CPD for teachers through transformative PLCs should not be a once-off event – they need to be continuing and have a logical flow of relevant information. Furthermore, the study showed the relevance of integrating IK as it improved the critical thinking capacity of the science teachers and helped

improve their conceptual understanding. The study created a space for the participants to reflect after each workshop. It was during these reflective spaces that I was able to observe how the teachers' perspectives and pedagogical insights in terms of IK integration into science changed or not and provided the necessary assistance. Furthermore, the use of reflective journals allowed the participants to have more time to reflect and new knowledge emerged through their reflections. Next, I present the conclusion of the study.

10.5 Conclusion of Study

This qualitative case study employed a transformative research approach guided by Ubuntu perspectives to leverage the use of a Lesson Study approach when working *with* science teachers on how to integrate IK to mediate learning of the topics of waves and sound and redox reactions in a township school. The study revealed that through collaboration with IKCs and tapping into their cultural heritage the integration of IK into science lessons was possible.

Thus, this study contributes to the decolonisation of the Western-based curriculum with its compartmentalised disciplines, which according to Ogunniyi and Ogawa (2008) has tended to displace the cultural heritage of an African child rather than accommodate it. This resonates with the post-apartheid and Bantu Education transformation agenda of making science relevant and accessible to township learners, particularly in South Africa. Moreover, this study revealed that the integration of IK enhances the conceptual understanding of teachers and ultimately learners become the beneficiaries. Furthermore, the use of storytelling and isiXhosa as our home language during the presentations by the IKCs proved to be invaluable cultural tools for effective communication in this study (Khupe, 2014). Likewise, the study showed that the use of easily accessible hands-on practical activities promotes interest and meaningful learning as opposed to rote learning offered by the WS (Asheela et al., 2021).

The study showed that the teachers viewed the teacher-teacher relationship as a crucial aspect of professional development. This was evident during workshop discussions, document analysis and co-development of exemplar lesson plans and our reflective space in our sharing circles. At the heart of any PLC is collaborative learning (Chauraya & Brodie, 2018). *Xa ndizakukhothama* (as I conclude), the evidence highlighted in this thesis indicates that this study contributes to new knowledge and lays a solid foundation for future studies of this nature.

10.6 Recommendations

This study showed that leveraging the use of a Lesson Study approach when working *with* science teachers on how to integrate IK to mediate learning of the topics of waves and sound and redox reactions in a township school, shifted the science teachers' ZPD and PCK positively. Moreover, it was observed that the two science teachers who volunteered to teach the post-intervention lessons were able to internalise our exemplar lessons and present them successfully. The learners' worldviews were taken into consideration, thus, making teaching and learning of science relevant and accessible to township learners.

Taking the findings into consideration, the study recommends that transformational PLCs be established in schools and that teachers should work in collaboration with IKCs to learn about IK which could be integrated into other science topics. This can be done using a Lesson Study approach from an African perspective for cultural revitalisation as advocated by Cocks et al. (2012) and Smith (2012). It is also recommended that teachers be supported in how to analyse documents and how to use the TSPCK components to unpack the curriculum. This might help the teachers to understand the curriculum needs better, to plan better, and hopefully to teach better. This in turn might stimulate learners' interest in choosing science beyond grade 9. To deal with language difficulties, perhaps township schools should consider the use of a dual medium as their official language of learning and teaching. In other words, I am suggesting that township schools should use English and isiXhosa (or any learners' vernacular) equally for teaching and learning, what Mapfumo (2024) refers to as translanguaging, which he argues helps in effective communication.

I cannot over-emphasise the importance of hands-on practical activities in science teaching. Thus, the study recommends that we promote the use of easily accessible resources when teaching science, especially in under-resourced schools to promote meaningful learning of science concepts. Next, I summarise the limitations of the study.

10.7 Limitations of Study

The first limitation of this study is that we used the topics of waves and sound and redox reactions as examples. Both topics are from the Secondary Phase and perhaps it would have been good if we could have co-developed other exemplar lessons in the Foundation Phase – Beginning knowledge (Nhase, 2019) and Intermediate Phase.

The second limitation is centred on time. The fact that the study was confined to a set period meant that I could not observe the science teachers' progress as they tried to implement what they had learned in other science topics.

Thirdly, load shedding limited the virtual interactions; for instance, the initial workshop on the Lesson Study approach could not take place because of load shedding and poor connectivity. Furthermore, load shedding delayed the progress of this study, as sometimes electricity was off from 19H00 to 23H00 and that affected me negatively because I had planned to work on my project for at least two hours every evening. *Athi amaXhosa utshaba lixesha* (Time wasted never returns).

Lastly, the unscheduled workshops by the Department of Education meant that we had to postpone some of our meetings and that affected the completion of the research process. Nonetheless, the study provides areas for future research.

10.8 Areas for Future Research

In my view, this study serves as a stepping-stone for further research on the integration of IK into science lessons. The study provides further suggestions for research focusing on the following:

- A similar study could be conducted using science teachers from different schools.
- An extension of this study at the post-doctorate level could be conducted as a longitudinal study over a longer period to see the teachers' professional development as time goes on.
- A study could be undertaken focusing on institutions of higher learning and the opportunities or hindrances of integrating IK to mediate learning.
- A study could be conducted focusing on leveraging the use of a Lesson Study approach when working *with* science subject advisors on how to integrate IK to mediate learning of any science topics of their choice.
- A study could be conducted to explore the effect of using isiXhosa during the presentations by the IKCs in this research or a new project.

10.9 My Reflections

I do not believe in coincidences or "it just happened", but rather I believe that God sets up opportunities for each one of us to fulfil our assignments in this gift of life. A practical example of what I am talking about is that in 2016, I was doing my honours degree in education on a part-time basis with Rhodes University, and towards the end of my honour's degree, Gxarha (my supervisor's clan name) who was on sabbatical leave, sacrificed his time and came back and introduced us to the concept of IK. Even though I did my junior degree at Fort Hare University, a traditionally Black university situated in one of the most remote towns in South Africa, it was the first time I had been introduced to IK. I found lessons on IK very interesting, partly because they were based more on our everyday experiences (which I could relate to) and partly due to the way Gxarha introduced IK which I found most fascinating. This triggered my research interest as a pure sciences student, and I saw an opportunity to develop myself and improve my teaching strategy. This is not a coincidence!

So, in 2018 I registered for my master's in science education at Rhodes University and obtained my degree in 2020. In my master's research project, I explored the affordances and hindrances when IK is integrated into the topic of waves and sound in a Grade 10 Physical Sciences township class and I worked with learners as my research participants. As noted earlier, I do not believe in coincidences – the findings of my master's research project which focused on the learners (Mayana, 2020), together with my upbringing and personal experiences as an African boy who grew up in the dusty streets of Tantyi location in Makhanda triggered my interest to do this research (see Section 1.3). This time around I worked with science teachers.

As indicated above, this study aimed to contribute towards the capacity-building of science teachers in addressing and hopefully overcoming the challenges that they experienced in their teaching practice in relation to the integration of IK into science lessons. Unlike the one-size-fits-all and once-off workshops by the Department of Education which use top-down approaches, in contrast, in this study, teachers were at the centre of using PLC. Moreover, we aimed to decolonise the science curriculum through a bottom-up approach as reiterated by scholars such as Seehawer (2018) and Mutanho (2021).

However, the research process did not go without challenges. One of the challenges was related to time management. Just when I thought I had organised my day well, and that during the day I was going to focus on my work, then in the evening spend some time with my family and late

at night focus on my studies, load shedding came – *Yaphasalaka ibhobhile* (that messed up my entire plan). I tried to wake up in the early hours of the morning when the electricity came back on, but it was extremely cold and I could not focus. Also, even if I woke up in those early hours, I was hit by the second wave of load shedding, so I could not keep the momentum.

The second challenge was caused by the unscheduled and untimely workshops for the teachers that were called at the 11th hour. That meant we had to reschedule our meetings as the PLC. Thirdly, the fact that Umhlekazi could not go to the sea with us so that we could witness *ukuhlwayela* (see Section 7.2.2.2) was a little disappointing. However, we understood because he explained to us that it was out of respect for the ancestors and his calling (Chilisa 2012; Mertens, 2010).

My third challenge was centred on the contradictions between Rhodes' research ethics policy and the Ubuntu principles embedded in IK. For instance, tension arose when I asked Majeke to sign the written consent form after he had verbally agreed to participate in this study. Majeke asked why and seemed to be offended by my request. Similarly, during the orientation workshop, Zizi asked the same question when I requested the science teachers to give me written permission (to use their photos in this thesis) over and above the consent forms they had already signed: "*Why must we give you a written permission because we have agreed to participate?"* It is probably statements like these that led Smith (2012, p. 118) to conclude that: "Community and Indigenous rights or views in this area are generally not recognised and not respected".

Another tension between the WS and Indigenous methodological approach is the ethics statement that says, "You can pull out of the study at any stage if you so choose". This was evident when I visited MaMcirha in her home to ask her to be one of the participants. MaMcirha's husband took offence to this statement and said: "*Nisamfunela ntoni xakanti angayeka, ningaske nifune omnye umntu ongazokuyeka*?" (Loosely translated, if you talk like that, it means you don't really need her help). It would probably come as a cultural shock to most White people that Black people are offended by this statement and view it as being rude and reckless. Like Mutanho (2021), this study offered the Ubuntu perspective as an alternative approach when researching with Indigenous people. The second cultural shock is that according to Indigenous protocols, you cannot ask a married woman directly to participate in your study but rather you must get her husband's permission (Mutanho, 2021, Seehawer, 2018).

Nonetheless, *Njengethole lomgquba* (as an African child myself), I managed to mediate these tensions using Ubuntu principles, but it was not easy.

However, despite these challenges, I have learned to be resilient and keep on pushing forward. My late mother's words echoed in my ears when she used to say: *"Andilifuni ibhetyebhetye mntwanam"* (Be strong my child). Also, my supervisor's words of encouragement kept me going. These have taught me that life is a journey, and indeed you do not cancel the journey because of a flat tyre or because you ran out of fuel.

On the other hand, the journey was rewarding as it contributed towards harnessing working relations; levelling of power gradients; opening doors to our classrooms and most importantly, sustainability of the school as a school of excellence in the township – and at the centre of it all, learners as the beneficiaries. Secondly, I believe that the bonds formed between the teachers and the community members, and between the teachers, will last for many years to come. Indeed, this study broke the barriers between the school and the community and taught us to value one another and appreciate the knowledge that the community members have – "*Ngokwenene siyazalana"* (We are family). We were humbled by the presentations by the IKCs and the skills, wisdom and knowledge they have. I thus concur with Vygotsky (1978), that indeed they are the MKOs. The contributions of my critical friends were phenomenal in that they contributed positively to our professional development. Ndlovu even went beyond just presenting and motivating our science teachers – this cannot go unnoticed in this study.

As I wrote this thesis, moving from one chapter to the next taught me that it does not get easier. For me, the writing of this final chapter was a more challenging exercise compared to writing the other chapters. This resonates with the words of one of the world's famous icons, Nelson Mandela when he was addressing the 2015 Annual Meeting in Abidjan: "After climbing a great hill, one only finds that there are many more hills to climb" (Mandela, 2015, p. 3). Indeed, I had to climb more hills during this research process, but I enjoyed the climb. I turned down two promotional posts; both were out of town (in 2021 and 2023) as a circuit manager because they would have compromised the completion of this study. Secondly, I turned them down because if I took the offer, it would mean I was going to be separated from my family and that did not resonate with my principles. I also had to climb the hill of doubt and failure; thank God the Holy Spirit gave me wisdom and strength and I completed this assignment. Lastly, I believe that this study has opened my eyes in so many ways, and the experiences from this study have equipped me to be a better teacher, a better colleague, a better headmaster and a better pastor.

References

Abend, G. (2008). The meaning of theory. *Sociological Theory*, *26*(2), 173-199.

Afonso-Nhalevilo, A. (2013). Rethinking the history of inclusion of IKS in school curricula: Endeavoring to legitimate the subject. *International Journal of Science and Mathematics Education, 11*(1), 23-42.

Agunbaide, E. A. (2021). *Exploring learners' proficiency in stoichiometry and attitudes towards science through process oriented guided inquiry learning (POGIL) intervention* [Unpublished PhD thesis]. Rhodes University.

Agunbiade, E. A. (2015). *Exploring the influence of learners' participation in an after-school science enrichment programme on their disposition towards science: A case study of Khanya Maths and Science Club* [Unpublished master's thesis]. Rhodes University.

Agunbiade, E., Ngcoza, K., Jawahar, K., & Sewry, J. (2017). An exploratory study of the relationship between learners' attitudes towards learning science and characteristics of an afterschool science club. *African Journal of Research in Mathematics, Science and Technology Education*. https://doi.org/10.1080/18117295.2017.1369274

Aikenhead, G. S. (2006). Towards decolonizing the pan-Canadian science framework. *Canadian Journal of Math, Science & Technology Education*, *6*(4), 387-399.

Aikenhead, G. S., & Jegede, O. J. (1999). Cross-cultural science education: A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching*, *36*(3), 269-287.

Ajzan, I. (1988). *Attitudes, personality and behavior.* Dorsey Press.

Alshwaikh, J., & Adler, J. (2017). Researchers and teachers as learners in lesson study. SAARMSTE *Book of Long Papers,* 2-14.

Asheela, E., Ngcoza, K. M., & Sewry, J. (2021). The use of easily accessible resources during hands-on practical activities in rural under-resourced Namibian schools. In U. Ramnarain (Ed.), *School science practical work in Africa* (pp. 14-31). Routledge.

Atallah, F., Bryant, S. L., & Dada, R. (2010). Learners' and teachers' conceptions and dispositions of mathematics from a Middle Eastern perspective. *US-China Education Review*, *7*(8), 43-49.

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education, 59*(5), 389-407.

Bantwini, B. (2012). Primary school science teachers' pespectives regarding their professional development: Implications for school districts in South Africa. *Professional Development in Education, 38*(4), 517-523.

Bantwini, B. D. (2019). Developing a culture of collaboration and learning among natural science teachers as a continuous professional development approach in a province in South Africa. *Teacher Development, 23*(2), 213-232.

Baquete, A. M., Grayson, D., & Mutimucuio, I. V. (2016). An exploration of indigenous knowledge related to physics concepts held by senior citizens of Chokwe, Mozambique. *International Journal of Science Education, 38*(1), 1-16.

Bayar, A. (2014). The components of effective professional development activities in terms of teachers' perspective. *Online Submission, 6*(2), 319-327.

Bertram, C., & Christiansen, I. (2019). *Understanding research*: *An introduction to reading research* (2nd ed.). Cape Town: Van Schaik.

Bhagwan, R., & Chan, C. L. (2014). Indigenous spirituality: An introduction. *Journal of Religion & Spirituality in Social Work: Social Thought, 33*(1), 1-3.

Botha, L. (2011). Mixing methods as a process towards indigenous methods. *International Journal of Inclusive Education, 16*(1), 57-70.

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal*, *9*(2), 27-40.

Breidlid, A. (2009). Culture, indigenous knowledge systems and sustainable development: A critical view of education in an African context. *International Journal of Educational Development, 29*, 140-148.

Breidlid, A. (2013). *Education, indigenous knowledges, and development in the Global South: Contesting knowledge for a sustainable future*. Routledge.

Brodie, K. (2013). The power of professional learning communities. *Education as Change, 17*(1), 5-18.

Brunner, K. (1969). 'Assumptions' and the cognitive quality of theories. Synthese, 501-525.

Carlson, J., & Daehler, K. R. (2019). The refined consensus model of pedagogical content knowledge in science education. In A. C. Hume (ed.), *Repositioning pedagogical content knowledge in teachers' knowledge for teaching science* (pp. 77-92). Springer.

Carr, T., Arcand, L., Roberts, R., Sedgewick, J., Ali, A., & Groot, G. (2020). The experiences of Indigenous people with cancer in Saskatchewan: A patient-oriented qualitative study using a sharing circle. *Canadian Medical Association Open Access Journal, 8*(4), E852-E859.

Cetin-Dindar, A., & Geban, O. (2017). Conceptual understanding of acids and bases concepts and motivation to learn chemistry. *The Journal of Educational Research*, *110*(1), 85-97.

Chang, R. (2008). *General chemistry: The essential concepts*. McGraw-Hill.

Chauraya, M., & Brodie, K. (2017). Learning in professional learning communities: Shifts in mathematics teachers' practices. *African Journal of Research in Mathematics, Science and Technology Education, 21*(3), 223-233.

Chauraya, M., & Brodie, K. (2018). Conversations in a professional learning community: An analysis of teacher learning opportunities in mathematics. *Pythagoras*, *39*(1), 1-9.

Chikamori, K., Tanimura, C., & Ueno, M. (2019). Transformational model of education for sustainable development (TMESD) as a learning process of socialization. *Journal of Critical Realism, 18*(4), 420-436.

Chilisa, B. (2012). *Indigenous research methodologies*. Sage.

Cimi, P. V., Ngcoza, K., & Dold, T. (2020). The role of ethnobotany in integrating Indigenous Knowledge in the discipline of science education: A study by the

herbarium of the Albany Museum in South Africa. *South African Museums Association Bulletin, 42*(1), 1-8.

Cobern, W. W., & Loving, C. C. (2001). Defining "science" in a multicultural world: Implications for science education. *Science Education*, *85*(1), 50-67.

Cocks, M.L., Alexander, J., & Dold, T. (2012). Inkcubeko Nendalo: A bio-cultural diversity schools education project in South Africa and its implications for inclusive indigenous knowledge systems (IKS) sustainability. *Journal of Education for Sustainable Development, 6*(2), 241-252.

Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (8th ed.). Routledge.

Corbin, J., & Strauss, A. (2008). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (3rd ed.). Sage.

Cordingley, P., Bell, M., Rundell, B., Evans, D., & Curtis, A. (2004). *How do collaborative and sustained CPD and sustained but not collaborative CPD affect teaching and learning*. EPPI-Centre, Institute of Education.

Creswell, J. W. (2008). *Educational research: Planning, conducting and evaluating quantitative and qualitative research* (3rd ed.). Pearson.

Creswell, J. W., & Creswell, J. D. (2018). *Research design: qualitative, quantitative, and mixed methods* (5th ed.). Sage.

Creswell, J. W., Ebersohn, L., Eloff, I., Ferreira, R., Ivankova, N. V., Jansen, J. D., Nieuwenhuis, J., Pietersen, J. & Plano Clark, V. L. (2016). *First steps in research* (2nd ed.). Schaik Publishers.

Cronje, A., De Beer, J., & Ankiewiez, P. (2015). The development and use of an instrument to investigate science teachers' views on indigenous knowledge. *African Journal of research in Mathematics, Science and Technology Education, 19*(3), 319-332.

Darling-Hammond, L. (2010). Teacher education and the American future. *Journal of Teacher Education, 61*(1-2), 35-47.

De Beer, J., & Mentz, E. (2016). *Self-directed learning: Lessons from indigenous knowledge holders for school science education.* ttps://uir.unisa.ac.za/bitstream/handle/10500/22868/Josef%20de%20Beer,%Elsa%20Mentz.pdf?sequence=1

De Beer, J., & Whitlock, E. (2009). Indigenous knowledge in the Life Sciences classroom: put on your De Bono hats! *The American Biology Teacher*, *71*(4), 209-216.

Dein, S., Cook, C. C. H., Powell, A., & Eagger, S. (2010). Religion, spirituality and mental health. *The Psychiatrist, 34*, 63-64.

Department of Basic Education. (2012). *Policy for Initial Professional Education Training (IPET) and Continuing Professional Teacher Development (CPTD).* Government Printers.

Department of Basic Education. (2018). *2017 National Senoir Certificate Diagnostic Report Part 1.* Department of Basic Education.

Department of Basic Education. (2021). *National Senior Certificate 2020 Diagnistic Report Part 1: Content Subjects.* Department of Basic Education.

Department of Education. (2011). *Curriculum and Assessment Policy Statement*. Government Printers.

Du Toit, M. H. (2017). *Students' difficulties with chemical reaction types* [Unpublished doctoral dissertation]. North-West University.

Duit, R., Treagust, D. F., & Widodo, A. (2008). Teaching science for conceptual change: theory and practice. In S. Vosniadou (Ed.), *International handbook of research on conceptual change* (pp. 629-646). Pearson.

Dziva, D., Mpofu, V., & Kusure, L. P. (2011). Teachers' conceptions of indigenous knowledge in science curriculum in the context of Mberengwa district, Zimbabwe. *African Journal of Educational and Technology, 1*(3), 88-102.

Ecklund, E. H. (2008). Religion and spirituality among scientists. *Contexts, 7*(1), 12-15.

Engeström, Y. (2001). Expansive learning at work: towards an activity-theoretical reconceptualization. *Journal of Education and Work, 14*(1), 133-156.

Erinosho, S. Y. (2013). Integrating indigenous science for enhanced learning: A Nigerian example. *International Journal for Cross-Disciplinary subjects in Education, 4*(2), 1137-1143.

Eun, B. (2008). Making connections: grounding professional development in the developmental theories of Vygotsky. *The Teacher Educator, 43*(2), 134-155.

Feiman-Nemser, S. (2001). From preparation to practice: Designing a continuum to strengthen and sustain teaching. *Teachers College Record, 103*(6), 1013-1055.

Fernandez, C. (2002). Learning from Japanese approaches to professional development: The case of lesson study. *Journal of Teacher Education, 53*(5), 393-405.

Fullan, M. (2011b). Whole system reform for innovative teaching and learning. Microsoft-ITL Research (Ed). *Innovative Teaching and Learning Research*, 30-39.

Gay, G. (1993). Building cultural bridges: A bold proposal for teacher education. *Education and Urban Society, 25*(3), 285-299.

Geddis, A. N., & Wood, E. (1997). Transforming subject matter and managing dilemmas: A case study in teacher education. *Teaching and Teacher Education, 13*(6), 611-26.

Gess-Newsome, J. (2015). A model of teacher professional knowledge and skill including PCK: Results of the thinking from the PCK Summit. In A. Hume, R. Cooper & A. Borowski (Eds.), *Repositioning pedagogical content knowledge in teachers' knowledge for teaching science* (p. 79). Springer.

Glasson, G. E., Mhango, N., Phiri, A., & Lanier, M. (2010). Sustainability science education in africa: negotiating indigenous ways of living with nature in the third space. *International Journal of Science Education, 32*(1), 125-141.

Glasson, G. E., Mhango, N., Phiri, A., & Lanier, M. (2010). Sustainability science education in Africa: Negotiating indigenous ways of living with nature in the third space. *International Journal of Science Education, 32*(1), 125-141.

Goodchild, S., & Ronning, F. (2014). Teaching mathematics at higher education. In H. Silverberg, T. Karki & M.S. Hannula (Eds.), *Proceedings of NORMA 14* (pp. 396-400).

Govender, N. (2014). Re-envisioning pedagogy for African Higher Education: Students' status of science and IKS via argumentation discourses. *Alternation Special Edition*, *12*, 358-384.

Govender, N. (2017). Physical sciences pre-service teachers' religious and scientific views regarding the origin of the universe and life. *International Journal of Science and Mathematics Education, 15*(2), 273-292. https://doi.org/10.1007/s10763-015-9695-5

Graven, M. (2012). The evolution of an instrument for accessing early learning mathematical dispositions. In *Early childhood educational research and development week programme proceedings* (pp. 53-55). Rhodes University.

Greenwood, D. J., Whyte, W. F., & Harkavy, I. (1993). Participatory action research as a process and as a goal. *Human Relations*, *46*(2), 175-192.

Guskey, T. R. (1994). Results - Results oriented professional development. In search of an optimal mix of effective practises. *Journal of Staff Development, 15*(4), 42-50.

Gwekwerere, Y. (2016). *Schooling and the African child. Bridging African epistemology and Eurocentric physical sciences*. Sense Publishing.

Haimene, J. S. (2023). *Exploring and expanding teachers' gender and culturally responsive practices when mediating the learning of chemistry in rural schools in Namibia* [Unpublished PhD thesis]. Rhodes University.

Halili, S. H. (2019). Technological advancements in education 4.0. *The Online Journal of Distance Education and e-Learning, 7*(1), 63-69.

Hart, C. (2018). Doing literature review: Releasing the research imagination (2nd ed.). Sage.

Hart, M. A. (2009). Anti-colonial indigenous social work. Reflections on an Aboriginal approach. In R. Sinclair, M. A. Hart & G. Bruyere (eds.), *Wicihitown: Aboriginal social work in canada* (pp. 25-41). Fernwood Publishing.

Hashondili, S. (2020). *Exploring working with Grade 6 Elementary Agricultural Science teachers on how to integrate local knowledge in food preservation* [Unpublished master's thesis]. Rhodes University.

Hatcher, A., Bartler, C., Marshall, A., & Marshall, M. (2009). Two-eyed seeing in the classroom environment: Concepts, approaches, and challenges. *Canadian Journal of Science, Mathematics, and Technology Education, 9*(3), 141-153. https://doi.org/10.1080/14926150903118342

Hewson, P. W., & Hewson, M. G. (1998). An appropriate conception of teaching science: A view from studies of science learning. *Science Education, 72*(5), 597-614.

Hewson, M., & Ogunniyi, M.B. (2011). Argumentation teaching as a method to introduce indigenous knowledge into science classrooms: Opportunities and challenges. *Cultural Studies of Science Education.*

Hicks, S. D. (2006). *Understanding tides*. US Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service.

Hodson, D. (1990). A critical look at practical work in school science. *School Science Review*, *70*(256), 33-40.

Hodson, D. (2009). *Teaching and learning about science: Language theories, methods, history, traditions and values*. Sense Publishers.

Holmes, A. G. (2020). Researcher positionality-A consideration of its influence and place in qualitative research-A new research guide. *Shanlax International Journal of Education*, *8*(4), 1-10.

Horkheimer, M. (1982). *Critical theory.* Seabury Press.

Horsthemke, K., & Schafer, M. (2007). Does 'African mathematics' facilitate access to mathematics? Towards an ongoing critical analysis of ethnomathematics in a South African context. *Pythagoras*, *65*, 2-9.

Iseke, J. (2013). Indigenous storytelling as research. *International Review of Qualitative Research, 6*(4), 559-577.

Jacobs, K. R. (2015). *The classroom implementation of indigenous knowledge in science curriculum teachers in the Western Cape province, South Africa* [Unpublished PhD thesis]. University of Cape Town.

Jegede, O. J. (1999). Science education in nonwestern cultures: Towards a theory of collateral learning. In L. M. Semali & J. L. Kincheloe (Eds.), *What is indigenous knowledge*? *Voices from the Academy* (pp. 119-142). Palmer Press.

Jones, M. E., & Hunter, J. (2003). Enshrining indigenous knowledge in the national science curriculum: Issues arising from the Maori case. Articulating development and strengthening local practices. *Indinga: African Journal of Indigenous Knowledge Systems, 3*(2), 103-111.

Kadis, J. (2015). *Acoustic*: *The study of sound waves*. www.educ/192a/lecture1 caustics.pdf

Kakambi, W. (2020). *Using the indigenous technology of dyeing and weaving African baskets as a cultural tool to mediate learning of chemical and physical changes* [Unpublished master's thesis]. Rhodes University.

Katz, M., & Nandi, N. (2021). Social media and medical education in the context of the COVID-19 pandemic: scoping review. *JMIR Medical Education, 7*(2), e25892.

Keane, M. (2021). Research ethics and diversity of worldviews: Integrated worlds and Ubuntu. *Scholarship of Teaching and Learning in the South, 5*(2), 22-35.

Keane, M., Khupe, C., & Muza, B. (2016). It matters who you are: Indigenous knowledge research. *Education as Change*, *20*(2), 163-183.

Kemmis, S. (2012). Researching educational praxis: Spectator and participant perspectives. *British Educational Research Journal, 38*(6), 885-905.

Kemmis, S., & Wilkinson, M. (1998). Participatory action research and the study of practice. In B. Atweh, S. Kemmis & P. Weeks (Eds.), *Action research in practice: Partnerships for justice in education* (pp. 21-36). Routledge.

Kemmis, S., McTaggart, R., & Nixon, R. (2014). *The action research planner: Doing critical participatory action research.* Springer.

Khupe, C. (2014). *Indigenous knowledge and science*: *Possibilities for integration* [Unpublished doctoral dissertation]. University of Witwatersrand.

Kibirige, I., & van Rooyen, H. (2006). Enriching science teaching through the inclusion of indigenous knowledge. Indigenous knowledge in the science classroom. In J. De Beer & H. van Rooyen (Eds.), *Teaching in the OBE Classroom* (pp. 235-247). Macmillan.

Kind, V. (2009). Pedagogical content knowledge in science education: Perspectives and potential for progress. *Studies in Science Education*, *45*(2), 169-204.

Klein, J. (2011). Indigenous knowledge and education-the case of the Nama people in Namibia. *Education as Change, 15*(1), 81-94.

Kovach, M. (2010). Conversation method in indigenous research. *First Peoples Child & Family Review, 5*, 40-48. https://doi.org/10.7202/1069060ar

Kuhlane, Z. (2011). *An investigation into benefits of integrating learners' prior knowledge and experiences during teaching and learning of acids and bases in Grade 7: A case study* [Unpublished master's thesis]. Rhodes University.

Lavalle, L. F. (2009). Practical application of an Indigenous research framework and two qualitative Indigenous research methods: Sharing circles and Anishnaabe symbol-based reflection. *International Journal of Qualitative Methods, 8*(1), 21-40.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press.

Le Grange, L. (2007). Integrating western and indigenous knowledge systems: The basis for effective science education in South Africa. *International Review of Education, 53*, 577-591.

Lee, L. H. J., & Tan, S. C. (2020). Teacher learning in Lesson Study: Affordances, disturbances, contradictions, and implications. *Teaching and Teacher Education, 89,* 102986.

Lemke, J. L. (1990). *Talking science*. *Language, learning, and values*. Ablex Publishing Corporation.

Lemke, J. L. (2001). Articulating communities: Sociocultural perspectives on science education. *Journal of Research in Science Teaching, 38*(3), 296-316.

Lenski, S. J., & Caskey, M. M. (2009). Using the lesson study approach to plan for student learning. Middle School Journal, 40(3), 50-57.

Lewis, C. (2002). Does lesson study have a future in the United States? *Nagoya Journal of Education and Human Development.*

Lewis, C. C., Perry, R. R., & Hurd, J. (2009). Improving mathematics instruction through lesson study: A theoretical model and North American case. *Journal of Mathematics Teacher Education, 12*(4), 285-304.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic observation*. Sage.

Liveve, A. K. (2017). *Exploring the possibility of integrating traditional music and dance into the design and delivery of lessons on the concepts of echo and waves in the grade 10 Physical Science sound topic* **[**Unpublished masters' thesis]. Rhodes University.

Liveve, A. K. (2022). *Revitalisation and indigenisation of the science curriculum through drum making, drumming, music and dance* [Unpublished doctoral thesis]. Rhodes University.

Mandela, N. R. (1994). *Long walk to freedom: The autobiography of Nelson Mandela.* Macdonald Purnell.

Mapfumo, A. (2024). *Supporting grade 12 physical sciences teachers in improving their PCK of the topic work and energy in the Eastern Cape Province* [Unpublished PhD thesis]. Rhodes University.

Maree, K. (2014). *First step in research*. van Schaik Publishers.

Masango, M. J. (2006). African spirituality that shapes the concept of Ubuntu. *Verbum et Ecclesia, 27*(3), 930-943.

Mateus, V., & Ngcoza, K.M. (2019). The making of clay pots and its relevance to school science: Reclaiming knowledge in the cultural practice of Ovambo people in Namibia. *Indilinga-African Journal of Indigenous Knowledge Systems*, *18*(1), 64-77.

Mavhunga, E. (2019). Exposing pathways for developing teacher pedagogical content knowledge at the topic level in science. In *Repositioning pedagogical content knowledge in teachers' knowledge for teaching science* (pp. 131-150). Springer.

Mavhunga, E., & Rollnick, M. (2013). Improving PCK of chemical equilibrium in pre-service teachers. *African Journal of Research in Mathematics, Science and Technology Education, 17*(1-2), 113-125.

Mavhunga, E., Ibrahim, B., Makomosela, Q., & Rollnick, R. (2016). Student teachers' competence to transfer strategies for developing PCK for electric circuits to another Physical Sciences topic. *African Journal of Research in Mathematics, Science and Technology Education, 20*(3), 299-213.

Mavuru, L. (2022). Reimagining indigenous knowledge in a multicultural science classroom. *International Journal of Inclusive Education*, 1-17. https://doi.org/10.1080/13603116.2022.2127498

Mavuru, L., & Ramnarain, U. (2020). Learners' socio-cultural backgrounds and science teaching and learning: a case study of township schools in South Africa. *Cultural Studies of Science Education, 15,* 1067-1095.

Maxwell, J. A. (2012). *Qualitative research design: An interactive approach* (Vol. 41). Sage.

Mayana, X. J. (2020). *Exploring affordances and hinderances when indigenous knowledge is integrated in the topic on waves and sound in a Grade 10 Physical Sciences township class* [Unpublished master's thesis]. Rhodes University.

Mazibe, E. N., Gaigher, E., & Coetzee, C. (2020). Comparing pedagogical content knowledge across fundamental concepts of electrostatics: A case of three pre-service teachers. *African Journal of Research in Mathematics, Science and Technology Education, 24*(2), 143-155.

Mazzocchi, F., Simandan, D., Demneh, M. T., Morgan, D. R., Ghazinoory, S., Saghafi, F., & Mirzaei, M. (2018). Why 'Integrating'Western science and Indigenous knowledge is not an easy task: What lessons could be learned for the future of knowledge. Journal of Futures Studies, 22(3), 19-34.

Mbiti, S. J. (1977). *Introduction to African religion*. Hennemann.

McMillan, J., & Schumacher, S. (2014). *Research in education: Evidence-based inquiry* (7th ed.). Pearson.

McRobbie, C., & Tobin, K. (1997). A social constructivist perspective on learning environments. *International Journal of Science Education*, *19*(2), 193-208.

Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation*. Jossey-Bass.

Mertens, D. M. (1999). Inclusive evaluation: Implications of transformative theory for evaluation. *American Journal of Evaluation, 20*(1), 1-14.

Mertens, D. M. (2010). Philosophy in mixed methods teaching: The transformative paradigm as illustration. *International Journal of Multiple Research Approaches, 4*(1), 9-18.

Mhakure, D., & Otulaja, F. S. (2017). Culturally-responsive pedagogy in science education: narrowing the divine between indigenous knowledge and scientific knowledge. In F. S. Otulaja & M. B. Ogunniyi (Eds), *The world of science education: A handbook of research in science education in Sub-Saharan Africa* (pp. 81-100). Sense Publishers.

Millar, R. (2004). *The role of practical work in the teaching and learning of science.* Department of Educational Studies.

Mosimege, M. D., & Onwu, G. (2004). Indigenous knowledge systems and science education. *Journal of the Southern African Association for Research in Mathematics, Science and Technology Education, 8*, 1-12.

Mothwa, M. M. (2011). *Teachers' experiences of incorporating indigenous knowledge in the life sciences classroom* [Unpublished master's thesis]. University of Johannesburg.

Msomi, N. N., & Akhurst, J. (2023). Prominent discourses in South African education from the perspective of community psychology: Challenges and opportunities for youth liberation and well-being. *Journal of Education (University of KwaZulu-Natal), 92,* 98-114.

Mthembu, M., Baiyegunhi, O., Mdleleni, Y., Ndlovu, L., Keal, H., Waddilove, K., Yarrow, J. C., Kasprowicz, v., Ndung'u, Y., & Wong, E. B. (2023). A powerpack of superscientists: An innovative concept by African scientists to address gender bias and inequity in science. *Welcome Open Research, 7*(87), 87-103.

Mucina, D. (2011). Moving beyond neo-colonialism to Ubuntu governance. In *The politics of cultural knowledge* (pp. 71-81). Brill.

Mucina, D. D. (2011). Story as research methodology. *AlterNative: An International Journal of Indigenous Peoples, 7*(1), 1-14.

Mukwambo, M., Ngcoza, K., & Chikunda, C. (2014). Africanisation, Ubuntu and IKS: A learner-centered approach. In C. I. O. Okeke, M. M. van Wyk & N. T. Phasha (Eds.), *Schooling, society and inclusive education: An African perspective*. Oxford University Press.

Mutanho, C. (2021). *Exploring how to support Bed Natural Sciences in-service teachers to develop exemplar lessons that integrate IK* [Unpublished doctoral thesis]. Rhodes University.

Nandjedi, F. N. (2022). *Mobilizing indigenous technologies of making Oshikundu and uumboloto to motivate and enable sense making of the topic carbon dioxide by grade 8 rural school learners* [Unpublished master's thesis]. Rhodes University.

National Commission on Teaching & America's Future (US). (1996). *What matters most: Teaching for America's future: Report of the National Commission on Teaching & America's Future.* The Commission.

Ngcoza, K. M. (2007). *Science teachers' transformative and continuous professional development: A journey towards capacity-building and reflexive practice* [Unpublished doctoral thesis]. Rhodes University.

Ngcoza, K. M. (2017). Negotiating boundary crossing from traditional or indigenous knowledge to modern western science: A South African Xhosa perspective. *Proceedings of EDULEARN 17 Conference* (pp. 7974-7983). Edulearn.

Ngcoza, K. M. (2019). Education for sustainable development at problem-posing nexus of re-appropriated heritage practices and science curriculum. *South African Journal of Environmental Education, 35*(1), 1-9.

Ngcoza, K. M., & Southwood, S. (2015). Professional development networks: From transmission to co-construction. *Perspectives in Education, 33*(1), 4-14.

Ngcoza, K. M., Sewry, J., Chikunda, C., & Kahenge, W. (2016). Stakeholders' perceptions of participation in science expos: A South African case study. *African Journal of Research in Mathematics, Science and Technology Education, 20*(2), 189-199.

Ngcoza, K., & Southwood, S. (2019). Webs of development: Professional networks as spaces for learning. *Pythagoras*, *40*(1), a409. https://doi.org/10.4102/Pythagoras.v40i1.409

Nhase, Z. (2019). *An exploration of how grade 3 Foundation phase teachers develop basic scientific process skills using inquiry-based approach in their classrooms* [Unpublished doctoral thesis]. Rhodes University.

Nhase, Z. (2019). *An exploration of how Grade 3 Foundation Phase teachers develop basic scientific process skills using an inquiry-based approach in their classrooms* [Unpublished doctoral thesis]. Rhodes University.

Nhase, Z., & Dube, B. (2023). *Integrating storytelling and inquiry-based approach as pedagogies of developing scientific skills in early childhood classrooms*. University of Free State.

Nikodemus, K. S. (2017). *Exploring how Grade 11 Physical Science learners make sense of the Concept of rates of reactions through the inclusion of the indigenous practice of making Oshikundu* [Unpublished master's thesis]. Rhodes University.

Nuntsu, S. N. (2021). *Mobilising stories about cultural beliefs and practices on traditional foods to contextualise the topic on nutrition in a Grade 6 township class* [Unpublished master's thesis]. Rhodes University.

Nyamakuti, M. N. (2020). *Exploring the effect of the indigenous technology of oil extraction on Grade 10 Biology learners' perspectives and sense making of enzymes* [Unpublished master's thesis]. Rhodes University.

Nyika, R. (2017). Views and experiences of Gweru rural primary school teachers on integrating indigenous knowledge system in the teaching and learning of environmental science in Zimbabwe. *Scholars Journal of Art, Humanities and Social Sciences, 5(*4A), 280-286.

Obomanu, B. J., & Onuoha, C. O. (2012). Students' conceptual difficulties in electrochemistry in senior secondary schools. *Journal of Emerging Trends in Educational Research and Policy Studies, 3*(1), 99-102.

Ogawa, M., & Ogunniyi, M. B. (2008). The prospects and challenges of training South African and Japanese educators to enact an indigenised science curriculum. *South African Journal of Higher Education, 22*(1), 175-190.

Ogunniyi, M. & Ogawa, M. (2008). The prospects and challenges of training South African and Japanese educators to enact an indigenized science curriculum. *South African Journal of Higher Education, 22*(1), 177-192.

Ogunniyi, M. B. (2007). Teacher's stances and practical arguments regarding a science-indigenous knowledge curriculum: Part 1. *International Journal of Science Education 29*(8), 963-986.

Ogunniyi, M. B. (2020). Tapping the potential of ubuntu for a science that promotes social justice and moral responsibility. In H. L. Yacoubian (Ed.), *Nature of science for social justice. Science: Philosophy, history and education.* Springer.

Ogunniyi, M. B., & Hewson, M. G. (2008). Effect of an argumentation-based course on teachers' disposition towards a science-indigenous knowledge curriculum. *International Journal of Environmental and Science Education*, *3*(4), 159-177.

Ogunnuyi, M. B. (2018). Indigenization of the curriculum: The prospects and challenges. In L. M. Semali & A. Singambi (Eds.), *Proceedings of the 4th Annual Conference of the African Association for the Study of Indigenous Knowledge Systems* (pp. 2-16). AASIKS.

Okanlawon, A. E. (2012). Chemistry lecturers' perceptions of "critical barriers" to successful solving of acid-base titration problems. *African Journal of Research in MST Education, 16*(3), 390-404.

O'Murchu, D. (2012). *In the beginning was the spirit: Science, religion, and indigenous spirituality.* Orbis Books.

Ono, Y., & Ferreira, J. (2010). A case study of continuing teacher professional development through lesson study in South Africa. *South African Journal of Education, 30*(1),59-74.

Onwu, G. O. M., & Mufundirwa, C. (2020). A two-eyed seeing context based approach for incorporating indigenous knowledge into school science teaching. *African Journal of Research in Mathematics, Science, and Technology Education, 24,* 229-240. https://doi.org/10.80/18117295.2020.1816700

Onwu, G., & Mosimege, M. (2004). Indigenous knowledge systems and science and technology education: A dialogue. *African Journal of Research in Mathematics, Science and Technology Education, 8*, 1–12.

Paik, S. H., Kim, S., & Kim, K. (2017) Suggestion of a viewpoint change for the classification criteria of redox reactions. *Journal Chemistry Education, 94*(5), 563-568.

Perry, R. R., & Lewis, C. C. (2009). What is successful adaptation of lesson study in the US? *Journal of Educational Change*, *10*(4), 365-391.

Petrou, M., & Goulding, M. (2011). Conceptualising teachers' mathematical knowledge in teaching. In T. Rowland & K. Ruthven (Eds.), *Mathematical knowledge in teaching* (pp. 9-25) (Vol. 50). Springer.

Reddy, V., Winnan, L., Juan, A., Arends, F., Hannan, S., Namone, C., Sekhejane, P., & Zulu, N. (2020). *TIMMS 2019: Highlights of South African Grade 9 Results in Mathematics and Science.* Human Sciences Research Council.

Ritskes, E. J. (2011). Connected: Indigenous spirituality as resistance in the classroom. In *Spirituality, education & society* (pp. 15-36). Brill.

Robinson, L. (2002). Participatory rural appraisal: A brief introduction. *Group Facilitation, 4,* 29-36.

Rojas-Drummond, S., Torreblanca, O., & Pedraza, H. (2013). Dialogic scaffolding': Enhancing learning and understanding in collaborative contexts. Learning, Culture and Social Interaction, 2(1), 11-21.

Roschelle, J. (1995). Learning in interactive environments. Prior knowledge and new experience. In J. Falk & L. Dierking (Eds.), *Public institutions for personal learning: Establishing a research agenda* (pp. 37-51). American Association of Museums.

Rothe, J. P., Ozegovic, D., & Carroll, L. J. (2009). Innovation in qualitative interviews: "sharing circles" in a First Nations community. *Injury Prevention, 15*(5), 334-340.

Sabitha, M. (2018). *Evaluate the effectiveness of hot foot bath with epsom salt on joint pain, stiffness, and physical function among patients with osteoarthritis in selected hospitals at Ottanchathiram* [Unpublished doctoral dissertation]. Bishop's College of Nursing.

Sannino, A., Engeström, Y., & Lemos, M. (2016). Formative interventions for expansive learning and transformative agency. *Journal of the Learning Sciences, 25*(4), 599-633.

Scotland, J. (2012). Exploring the philosophical underpinnings of research: Relating ontology and epistemology to the methodology and methods of the scientific, interpretive, and critical research paradigms. *English Language Teaching, 5*(9), 9-16.

Sedlacek, M., & Sedova, K. (2017). How many are talking? The role of collectivity in dialogic teaching. *International Journal of Educational research, 85*, 99-108.

Seehawer, M. (2023). Research agendas in an Ubuntu paradigm. *Scholarship of Teaching and Learning in the South, 7*(1), 41-61.

Seehawer, M. K. (2018). Decolonising research in a Sub-Saharan African context: exploring Ubuntu as a foundation for research methodology, ethics and agenda. *International Journal of Social Research Methodology, 21*(4), 453-466.

Seehawer, M. K. (2021). *Exploring how South African science teachers can integrate student's indigenous knowledge into their regular teaching. Approaching bottom-up decolonisation through participatory action research* [Unpublished PhD thesis]. Oslo Metropolitan University.

Seehawer, M., & Breidlid, A. (2021). Dialogue between epistemologies as quality education: Integrating knowledges in sub-Saharan African classrooms to foster sustainability learning and contextually relevant education. *Social Sciences & Humanities Open,* 1-8. www.sciencedirect.com/journal/social-sciences-and-humanities-open

Sewry, J., Ngqinambi, A., & Ngcoza, K. (2023). Attitudes to science when doing kitchen chemistry at science clubs. *South African Journal of Chemistry, 77*, 74-79.

Shinana, E. N. L. (2019). *Mobilising indigenous practice of making Oshikundu using inquiry based approach to support Grade 8 Life Science teachers in mediating learning of enzymes* [Unpublished master's thesis]. Rhodes University.

Shinana, E., Ngcoza, K. M., & Mavhunga, E. (2021). Development of teachers' PCK for a scientific inquiry-based teaching approach in Namibia's rural schools. *African Journal of Research in Mathematics, Science and Technology Education, 25*(1),1-12.

Shiza, E. & Emeagwali, G. (2016). Interconnecting history, African indigenous knowledge systems and science. In *African indigenous knowledge and the sciences* (pp. 1-11). Brill Sense.

Shizha, E. (2007). Critical analysis of problems encountered in incorporating indigenous knowledge in science teaching by primary school teachers in Zimbabwe. *The Alberta Journal of Educational Research, 53*(3), 302-319.

Shulman, L. S. (1986). *Those who understand. Knowledge growth in teaching*. Stanford University.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, *57*(1), 1-23.

Simasiku, F. S. (2022). *Leveraging a peer-learning community and expert community members in the integration of indigenous knowledge into the learning and teaching of Grade 10 Chemistry on the rate of reactions* [Unpublished doctoral thesis]. Rhodes University.

Simpson, L. B. (2014). Land as pedagogy: Nishnaabeg intelligence and rebellious transformation. *Decolonisation: Indigeneity, 3*(3), 1-25.

Simsek, P., & Kabapinar, K. (2010). The effect of inquiry-based learning on elementary students' conceptual understanding of matter, scientific process skills and science attitudes. *Procedia, Social and Behavioural Sciences, 2*, 1190-1194.

Smetacek, V., & Zingone, A. (2013). Green and golden seaweed tides on the rise. Nature, 504(7478), 84-88.

Smith, L. T. (1999). *Decolonizing methodologies: Research and indigenous peoples.* Zed Books.

Smith, L. T. (2012). *Decolonizing methodologies: Research and indigenous peoples* (2nd ed.). Zed Books.

Smith, P. H., Meyers, A. R., & Cook, H. J. (Eds.). (2017). *Ways of making and knowing: The material culture of empirical knowledge*. Bard Graduate Center.

Snively, G. J., & Williams. L. B. (2008). "Coming to know". Weaving Aboriginal and western science knowledge, language, and literacy into science classroom. *Educational Studies in Language and Literature, 8*, 109-133.

Southerland, S. A. (2000). Epistemic universalism and the shortcomings of curricular multicultural science education. *Science Education*, *9*, 289-307.

Stott, D. (2016). Making sense of the ZPD: an organising framework for mathematics education research. *African Journal of Research in Mathematics, Science and Technology Education*, *20*(1), 25-34.

Struthers, R., Hodge, F. S., Geishirt-Cantrell, B., & De Cora, L. (2003). Participant experiences of talking circles on type 2 diabetes in two Northern Plains American Indian Tribes. *Qualitative Health Research, 13,* 1094–-115.

Tachine, A. R., Bird, E. Y., & Cabrera, N. L. (2016). Sharing circles: An Indigenous methodological approach for researching with groups of Indigenous peoples. *International Review of Qualitative Research, 9*(3), 277-295.

Taylor, D. L., & Cameron, A. (2016). Valuing IKS in successive South African physical sciences curricula. *African Journal of Research in Mathematics, Science and Technology Education, 20*(1), 35-44.

Taylor, N. (1999). Curriculum 2005: Finding a balance between school and everyday knowledges. In N. Taylor & P. Vinjevold (Eds.), *Getting learning right: Report of the president's education initiative research project* (pp. 105-130). Joint Education Trust.

Thomas, G. (2013). *How to do your research project* (2nd ed.). Sage.

Tyeda, N. (2024). *Mediating learning of nutrition through traditional food processing and preservation to grade 6 rural school learners* [Unpublished master's thesis]. Rhodes University.

United Nations Educational, Scientific & Cultural Organization. (1999). *Cultural challenges of the International Decade of the World's Indigenous People*. UNESCO.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Webb, P. (2013). Xhosa indigenous knowledge: Stakeholder awareness, value and choice. *International Journal of Science and Mathematics Education, 11*(1), 89-110.

Wellington, J., & Osborne, J. (2001). *Language and literacy in science education*. McGraw-Hill Education.

Wenger, E. (1998). *Communities of practice*: *Learning meaning, and identity.* Cambridge University Press.

Wilson, S. (2008). *Research in ceremony*: *Indigenous research methods*. Fernwood Publishing.

Wong, K. Y., Casey, R. G., & Wahl, F. M. (1982). Document analysis system. *IBM Journal of Research and Development*, *26*(6), 647-656.

Wood, D., Bruner, S., & Ross, J. (1976). The role of tutoring in problem solving. Child Psychol. Psychiatry, 17, 89-100.

Woodley, E. (2009). Practical work in school science – Why is it important? *School Science Review*, *91*(335).

Wyatt, T. R., de Dousa, E. B. C., & Mendenhall, S. C. (2017). Professional development as a process of cultural brokering: Positioning coaches as cultural brokers. *Journal of Educational Research and Prcatice, 7,* 95-110.

Yusof, Y. M., Zakaria, E., & Maat, S. M. (2012). Teachers' general pedagogical content knowledge (PCK) and content knowledge of algebra. *The Social Sciences*, *7*(5), 668-672.

Appendices

APPENDIX A: Research Ethics Clearance

Rhodes University, Education Faculty
Research Ethics Committee
PO Box 94, Makhanda, 6140, South Africa
Tel: +27 (0) 46 603 8393
Fax: +27 (0) 46 603 8028
email: e.rosenberg@ru.ac.za

https://www.ru.ac.za/researchgateway/ethics/

2 August 2022

Prof Kenneth Ngcoza

Education Department

K.Ngcoza@ru.ac.za

Dear Prof Kenneth Ngcoza and Mr Xolani Justice Mayana

Re: Using a Lesson Study approach focusing on working with science teachers on how to integrate indigenous knowledge in a township school.

APPLICATION NUMBER: 2022-5720-6866

This letter confirms that your research ethics application has been reviewed and **APPROVED** by the Education Faculty Research Ethics Committee (EF-REC). Your permission letter(s) where applicable have been received and you are free to proceed with your study.

Approval is granted for 1 year. An annual progress report is required in order to renew approval for an additional period. You will receive an email notifying you when the progress report is due.

Should any substantive change(s) be made during the research process, that may have ethical implications, you should notify the Education Faculty REC Chair via email. This includes changes in investigators. The REC Chair will advise as to whether a new application is necessary.

Do keep this clearance letter secure and accessible throughout your study and after its completion. It will be needed when a thesis is examined and when publications are submitted to journals.

Please also submit a brief report to the REC Chair on the completion of the research. This can be done via email. The purpose of this report is to indicate whether the research was conducted successfully and whether any ethics-related matters arose that the committee should be aware of, in order to guide future studies.

Sincerely,

Prof Eureta Rosenberg

Chair: Education Faculty Research Ethics Committee

Page 1 of 1

APPENDIX B1(a): Permission Letter to the District Director of Sarah Baartman

The District Director

Sarah Baartman District

Eastern Cape Department of Education

PO Box

Graff Reinnet

Dear Sir

Re: Request for permission to conduct educational research with teachers at XXX Combined School in Sarah Baartman District

I am Xolani Justice Mayana (Student number:92M2833), a part-time student doing PhD in Science Education with Rhodes University, South Africa and a Principal of XXX Combined. I am a Mathematics and science teacher at XXX Combined School. I hereby humbly request your permission to conduct a research study with the teachers at XXX Combined School which is in your district for at least eight weeks starting in July 2022. The study will require five science teachers and two language teachers to be co-researchers with myself. The purpose of this study is to explore the use of a Lesson Study approach when working with science teachers on how to integrate indigenous knowledge to mediate learning of the topics on waves and sound and redox reactions in a township school. This is intended to make science accessible and relevant to teachers and ultimately to learners as beneficiaries. Four expert community members and two university lecturers will be presenting to the teachers during the research process. This study is developmental in nature as various workshops such as workshop on document analysis and workshop on Lesson Study will be conducted by two different university lecturers with the hope of developing the teachers' PCK. A written consent will be sought from all participants and from the parents of the learners (who will be in class during lessons observations and those that will be presenting their reflections to the teachers). I would like to assure your office that, should I be granted permission, the research ethics will apply throughout the process of the study. Identity of participants and their views will be treated with high degree of confidentiality. Your consideration in this regard will be highly appreciated.

Yours Sincerely

APPENDIX B1(b): Response From the District Director of Sarah Baartman

TO : ***Mr XJ Mayana***

FROM : ***Mr Godlo***

SUBJECT : ***Research at XXX Combined School***

DATE : ***18 July 2022***

Dear Sir

Request for permission to conduct educational research with teachers at XXX Combined School in Sarah Baartman District.

I hereby grant permission on your request to conduct a PhD in Science Education with Rhodes University, South Africa on the integration of local indigenous knowledge in Science at XXX Combined School.

District Director

Sarah Baartman Education District

APPENDIX B2: Letter to the Deputy Principal of XXX Combined School

The Deputy Principal

XXX Combined School

Grahamstown CMC

Sarah Baartman District

Dear Sir

Re: Request for permission to conduct educational research with teachers at XXX Combined School in Sarah Baartman District

I am Xolani Justice Mayana (Student number: 92M2833), a part-time student doing PhD in Science Education with Rhodes University, South Africa. I am a Mathematics and science teacher at XXX Combined School. I hereby humbly request your permission to conduct a research study with five science and two language teachers at XXX Combined School for at least eight weeks from July 2022. The study will require the science teachers to be co-researchers with myself, and the language teachers to be my critical friends and assist with language issues. In addition, two university lecturers and four expert community members will present to the participants. The purpose of this study is to explore the use of a Lesson Study approach when working with science teachers on how to integrate indigenous knowledge to mediate learning of the topics on waves and sound and redox reactions in a township school. This is intended to make science accessible and relevant to teachers and ultimately to learners as beneficiaries. A written consent will be sought from the teachers and the parents of the learners (who will be in class during lessons observations and those that will be presenting their reflections to the teachers). I would like to assure you that, should I be granted permission, the research ethics will apply throughout the process of the study. Identity of participants and their views will be treated with high degree of confidentiality. Your consideration in this regard will be highly appreciated.

Yours Sincerely

XJ Mayana (Rhodes University Student)

APPENDIX B3(a): Letter to the Community Members

Enquiries: Mr XJ Mayana

Cell number: 0605093028

Dear Sir

RE: PERMISSION LETTER: PRESENTATION AT XXX COMBINED SCHOOL

I am Xolani Justice Mayana, a part-time student doing PhD in science education at Rhodes University, South Africa. I am also the principal and Mathematics and Science teacher at XXX Combined School. I hereby humbly request your permission to be a research participant in my research project that I will be conducting with my science teachers at XXX Combined. The purpose of this study is to explore the use of a Lesson Study approach when working with science teachers on how to integrate indigenous knowledge to mediate learning of the topics on waves and sound and redox reactions in a township school. I plan to conduct the study for about eight weeks from July 2022.

Since we will be concentrating on the study on waves and sound and redox reactions, your main role will be to present to the science teachers your local knowledge or indigenous knowledge related to the two topics of interest and related cultural practices.

Your participation in this research study is completely voluntary and you can withdraw at any time you wish (this does not mean I do not value your participation, but it is one of the requirements at Rhodes that participants should be informed in writing that they reserve this right). Your participation in this study will be highly appreciated. I will ensure that your identity will be treated with high degree of confidentiality and because we will be co-creating knowledge anonymity is not possible.

I henceforth request you to indicate your choice by making a tick (✓) in an appropriate box below.

Agree ☐

Not agree ☐

Signature:……..

Your cooperation will be highly appreciated

Yours Sincerely

XJ Mayana

APPENDIX B3(b): Translation

Mnumzana obekekileyo,

Igama lam ngu Xolani Justice Mayana umfundisintsapho kweZezibalo neNzululwazi eXXX Combined School. Ndicela ukuba ube yinxalenye kuphando ulunxulumene nezifundo zam zakwi Dyunivesithi yase Rhodes. Uphando lwam ndizakulenza eXXX CS, lunxulumene nokuphanda ukuba lukhonana ulwazi lwenveli lwasekuhlaleni elinokunceda abafundisintsapho ukuqinisekisa ukuba indlela abafundisa ngayo yenza umdla kwaye iyalandeleka kubafundi beNzululwazi, ngenjongo yokuphuhlisa indlela abaqhuba ngayo kwezizifundo.

Oluphando luzakuthatha izigaba ezintandathu. Isigaba sesibini sinxulumene nokufundisa nokucacisela ootitshala beNzululwazi ukuba luthini ulwazi lwemveli ngolwandle kwakunye neenkolo zakwantu. Injongo ephambili yoluphando kukuqwalasela ukuba kungakwazi ukuhlanganiswa ulwazi lwemveli neNzululwazi, ukuzama ukukhulisa umdla wabafundi kwezeNzululwazi. Ndiyazithoba ndikucela kananjalo ukuba uzokusifundisa, ngolwazi lwemveli ngolwandle kwakunye neenkolo zoluntu ezidibene nolwandle namaza nokwenza isonka sakwantu.

Ndakuvuyiswa yinxaxheba yakho koluphando. Imithetho yeDyunivesithi ke ayibabopheleli abathathi nxaxheba into ethetha ukuba banakho ukurhoxa nanini na xa befuna. Ndiyafuna ukuqinisekisa ukubaluleke kwenxaxheba yakho endingavuya ukuba lentetho ayiyi kukuthibaza okanye ikutyhafise. Ndiyakuqinisekisa nakanjalo ukuba ulwazi olufumaneke kulophando aliyikunikwa nabanina ngaphandle kwemvume yakho. Ukanti, igama lakho aliyikuchazwa esidlangaleleni ngaphandle kwemvume yakho. Ndikwacela kananjalo imvume yakho yokuba xa uzokucacisela ootitshala yonke ingcaciso ishicelelwe kananjalo ukuba unakho uphumelele ukuzokubona indlela ootitshala abazakulisebenzisa ngayo uncedo lwakho neemfundiso zakho kumagumbi okufundela.

Ukuba unombuzo malunga noluphando, nceda uqhagamishelane nam kolu cingo 0605093028, xj.mayana@gmail.com) okanye ingqonyela nengqonyelakazi endiphantsi kwazo uProf. Ken Ngcoza (k.ngcoza@ru.ac.za) (046-6037269) okwiSebe lwezeMfundo eRhodes Dyunivesithi, kwakunye noNkosikazi uJoyce Sewry (J.Sewry@ru.ac.za) okwiSebe lezeNzululwazi eRhodes Dyunivesithi.

Maz'enethole!

Ndiyakucela kananjalo ukuba uncede uzalise esi siqendu silandelayo.

Mna…..…….. (Igama lakho)

Ndiyavuma ☐ OKANYE Andivumi ☐ (Khetha ngokufaka ✓) ukuthabatha inxaxheba koluphando.

Tyikitya…….

Inombolo yomxeba……

APPENDIX B4(a): Letter to the Parents/Guardians

Enquiries: Mr Mayana XJ

Cell number: 0605093028

Dear Sir/Madam

Re: Participation in research on the integration of local or indigenous knowledge when teaching the topics of waves and sound and redox reactions at XXX Combined School.

I am Xolani Justice Mayana, a part-time student doing PhD in Science Education with Rhodes University, South Africa. I am a Mathematics and Science teacher at XXX Combined School. I hereby humbly request your permission for me to conduct a research study with your child who is studying at XXX Combined. Should you agree, your child will present his or her journal reflections to the participating teachers and will be engaged in a class that is going to be taught by the participating teachers during teaching and learning of the topics of waves and sound and redox reactions. I plan to conduct the study for about eight weeks from July 2022.

The purpose of this study is to explore the use of a Lesson Study approach when working with science teachers on how to integrate indigenous knowledge to mediate learning of the topics on waves and sound and redox reactions in a township school. Kindly be informed that participation in this study is voluntary. It is therefore the right of the parent to decide whether his/her child should participate or not. Also, participants are free to withdraw any time as they wish to do so. I request your permission to videotape the lessons and the videos will be used for the purposes of this study only. The identity and views of the participants will be treated with high degree of confidentiality and anonymity, and data that will be collected will not be used for other purposes apart from this study.

If you have any question about the research, please feel free to contact me at 0605093028, xj.mayana@gmail.com or my supervisors Prof Ken Ngcoza at k.ngcoza@ru,ac,za and Mrs Joyce Sewry, J.Sewry@ru.ac.za.

Lastly, if you agree for your child to participate in this research, please complete the consent form below.

I……..(full name of parent/guardian), hereby confirm that I understand the content of this document and the nature of the research. I hereby give permission to …….(name of the child) to participate in the study.

Yours Sincerely

XJ Mayana

APPENDIX B4(b): Translation

Mzali obekekileyo,

Igama lam ngu Xolani Justice Mayana umfundisintsapho kweZezibalo neNzululwazi eXXX Combined School. Ndicela ukuba umntwana wakho abeyinxalenye kuphando ulunxulumene nezifundo zam zakwi Dyunivesithi yase Rhodes. Uphando lwam ndizakulenza eXXX Combined School, lunxulumene nokuphanda ukuba umndla wabafundi ungakhula akanye udodobale xa kufundiswa iNzululazwi kudityaniswa ulwazi nenkcubeko efumaneka eluntwini nasekuhlaleni ngokubanzi xa kufundiswa ngolwandle namaza kwakunye neenkolo zoluntu ezidibandakanya ulwandle nokwenza isonka sesintu kusetyenziswa ulwazi lwemveli.

Oluphando luzakuthatha izigaba ezintandathu. Umntwana wakho uyakube esegumbini lokufundela efundiswa ngumfundisintsapho wakhe, ekwafunda kananjalo icwecwe lakhe lokucholachola indlela ekufundiswa ngayo, sicela imvume yokushicelela esosifundo. Injongo ephambili yoluphando kukuqwalasela ukuba kungakwazi ukuhlanganiswa ulwazi lwemveli nenzululwazi, ukuzama ukukhulisa umdla wabafundi kwezeNzululwazi. Ndiyazithoba ndikucela kananjalo ukuba umvumele umntwana wakho abe yinxalenye yoluphando.

Ndakuvuyiswa kakhulu yimvume yakho. Imithetho yeDyunivesithi ke ayibabopheleli abathathi nxaxheba into ethetha ukuba banakho ukurhoxa nanini na xa befuna. Ndiyakuqinisekisa nakanjalo ukuba ulwazi olufumaneke kulophando aliyikunikwa nabanina ngaphandle kwemvume yakho. Ukanti, igama lamntwana aliyikuchazwa esidlangaleleni ngaphandle kwemvume yakho kwakunye neyakhe. Siye ke safumanisa ukuba masenze uphando lokuba sazi ukuba yintoni eyenza umdla nendlela abacinga ngayo abantwana xa beyinxalenye kusenziwa uphando nzulu kwizifundo zeNzululwazi ingakumbi kwizinto zaselunxwemeni nezakwantu.

Ukuba unombuzo malunga noluphando, nceda uqhagamishelane nam kolu cingo 0605093028, xj.mayana@gmail.com) okanye ingqonyela nengqonyelakazi endiphantsi kwazo uProf. Ken Ngcoza (k.ngcoza@ru.ac.za) (046-6037269) okwiSebe lwezeMfundo eRhodes Dyunivesithi, kwakunye noNkosikazi u Joyce Sewry (J.Sewry@ru.ac.za) okwisebe lezeNzululwazi eRhodes Dyunivesithi.

Maz'enethole!

Ndiyakucela kananjalo ukuba uncede uzalise esi siqendu silandelayo.

Mna mzali okanye mmeli mzali …….. (Igama lakho), ka ……..(Igama lomntwana wakho)

Ndiyavuma ☐ OKANYE Andivumi ☐ (Khetha ngokufaka X) ukuba athathe inxaxheba koluphando.

Tyikitya…….

Inombolo yomxeba……

APPENDIX B5: Letter to the Participants/Teachers

RHODES UNIVERSITY
Where leaders learn

RESEARCH PARTICIPANT INFORMED CONSENT LETTER

(PARTICIPANT/TEACHERS)

PROJECT TITLE: Using a Lesson Study approach focusing on working *with* science teachers on how to integrate indigenous knowledge in a township school.

Xolani Justice Mayana (92M2833), currently a PhD student at Rhodes University, has requested my permission to participate in the above-mentioned research project.

The nature and purpose of the research project and of this informed consent declaration have been clearly explained to me in a language that I understand.

I am therefore aware that:

1. The purpose of this study is to explore the use of a Lesson Study approach when working *with* science teachers on how to integrate IK to mediate learning of the topics on waves and sound and redox reactions in a township school. The main reason for this is to make science accessible and relevant to teachers who are regarded as learners in this study.

2. The intervention for this study will be composed of at least **eight** two-hour long workshops. During the workshops, data will be gathered through; photos, videotaping, participant observation, reflective journaling and document

analysis. The workshops will be conducted at a place and time that is convenient to me and the other participants.

3. I will be interviewed individually and/or in a focus group interview format whereby all the COVID-19 protocols will be observed. Should the COVID-19 restrictions be in force, Google Meeting or Zoom or WhatsApp will be used with my permission. The interview will take approximately 30-45 minutes and will be audio-recorded with my permission.

4. By participating in this research project, I will contribute to knowledge and understanding in the mediation of learning of the topics on waves and sound and redox reactions.

5. My participation is entirely voluntary and should I at any stage wish to withdraw from further participation, I may do so without any prejudice.

6. I understand that participating in this study is voluntary and that I will not be compensated for participating.

7. There may be risks associated with my participation in the project. I am therefore aware that of the following steps:

    a) All information shared in the group is strictly confidential and will not be used for purpose other than of the above-mentioned research project.
    b) All the data collected will be kept in a locked cupboard and electronic data will be kept in a computer only accessible through a secure password.
    c) The researcher intends to publish the research findings in the form of a thesis towards a PhD degree in Science Education, and later present it in papers conferences or journal articles, this means anonymity will be impossible. However, confidentiality will be maintained.

8. Any further questions that I might have concerning the research or my participation will be answered by the Rhodes PhD student (xj.mayana@gmail.com) or the supervisor Professor Kenneth Mlungisi Ngcoza (k.ngcoza@ru.ac.za).

9. By signing this informed consent declaration, there are no legal implications.

10. A copy of this informed consent declaration will be kept in a safe place by the researcher.

I, ……have read the above information or confirm that the above information has been explained to me in a language that I understand. I am therefore aware of this document's contents. I have asked all questions that I wished to ask, and these have been answered to my satisfaction. I fully understand what is expected of me during the research.

I have not been coerced or pressurised in any way, and I understand that anonymity might not be possible because we will be co-creating knowledge in this study. I therefore voluntarily agree to participate in the above-mentioned research project.

…….. …….

Participant's signature Witness

Date …….. Date ……..

Rhodes University, Research Office, Ethics

Ethics Coordinator: ethics-committee@ru.ac.za

T: +27 (0) 46 603 7335 F: +27 (0) 82 739 4378

Room 220, Main Admin Building, Drostdy Road, Makhanda, 6139

APPENDIX B6: Assent Letter to the Learner

Enquiries: Mr Xolani J Mayana

Cell number: 0605093028

Dear …… (Learner Name)

Re: Participation in research on the integration of the indigenous knowledge Using a Lesson Study approach focusing on working with science teachers when teaching the topic on waves and sound and redox reactions to Grade 10 & 11 classes.

I am Xolani Justice Mayana, a part-time student doing PhD in Science Education at Rhodes University, South Africa. I am Mathematics and Physical Sciences teacher at XXXX Combined School. I hereby humbly request your permission for me to conduct a research study with you present in class during teaching and learning of the topic on waves and sound and redox reactions. The study will focus on teachers' integration of Indigenous knowledge Using a Lesson Study approach when teaching the topic on waves and sound and redox reactions to Grade 10 & 11 classes. You will be required to (a) be present in class during those lessons, (b) participate in class discussions and write your reflections about the lessons, (c) interact with the teachers who will be presenting about indigenous knowledge and related cultural practices about the sea and homemade bread, and these activities will be observed and videotaped. A written consent will be sought from your parents or guardians. I plan to conduct the study for about eight weeks from July 2022 and the lessons will be conducted in the afternoon from 2pm to 3pm.

I would like to assure you that, should I be granted permission, the research ethics will apply throughout the process of the study. Kindly be informed that participation in this study is voluntary. It is therefore your right to decide whether you wish to participate or not. Also, participants are free to withdraw at any time of the study as they wish to do. The data that will be collected will not be used for other purposes apart from the study. Please note: Extra support and activities such as worksheets, video lessons and other relevant teaching materials will be made available for all those learners who do not wish to be part of this research, and they will not be disadvantaged in any way. So, if you choose not to participate you will not be disadvantaged in any way.

If you have any question about the research, please feel free to contact me at 0605093028, (xj.mayana@gmail.com) or my supervisors Prof. Kenneth M. Ngcoza at (k.ngcoza@ru.ac.za) and Mrs Joyce Sewry at (J.Sewry@ru.ac.za).

Lastly, if you agree or do not agree to participate in this research, please complete the consent form below.

I …… (full name of the learner), hereby confirm that I understand the content of this document and the nature of research. I henceforth request you to indicate your choice by making a tick (√) in an appropriate box below.

Agree to participate in the study □

Do not wish to participate in the study □

Signature: ---------- Date :----------

Your cooperation will be highly appreciated in this regard.

Yours sincerely

XJ Mayana

APPENDIX C: Data-Gathering Tools and Methods

Table 1: Shows the tools, methods and the purpose for the gathering of information

Phase	**Method to be used to gather data**	**Purpose**	**Research questions**
Phase 1	Semi-structured interviews	To solicit teachers' views and perspectives on the integration of IK in science lessons. Thereafter I will observe two teachers teaching the traditional lessons on waves and sound and redox reactions. This will be followed by three different workshops (two workshops on document analysis and two workshops on Lesson Studies by critical friends respectively, and one workshop on reflections)	1
Phase 2	Document analysis, workshop discussions and reflections	To analyse identified science textbooks, grade 10- 12 Physical Sciences syllabus, Scheme of work, ATP, CAPS documents on the two topics: Waves and sound, and the redox reactions, examiners' report for the past five years-2017-2021, and at least the past three years end of year examinations (focusing on the two topics). This will be followed by two workshops	2

Phase 3	Participatory observations and journal reflections	To explore if learning opportunities are created (or not) during the presentations by expert community members	3
Phase 4	Group Reflections (Workshop discussions and Journal reflections)	The PLC will reflect on the demonstration and explanation received from the community members and the document analysis. Co-develop exemplar lessons on waves and sound, and redox reactions	4
Phase 5	Lesson Observations (videotaped lessons), stimulated recall-interviews and journal reflections	At least three science teachers will enact the lesson. TSPCK components for the transformation of knowledge will be used. .	5
Phase 6	Participatory observation and journal reflections kitchen hands-on practical activity (on redox reactions)	Kitchen hands-on practical activity (on redox reactions). To assist teachers to mediate teaching and learning of the redox reactions	4

APPENDIX D: Research Process

Phase: 1

Semi-structured interview (sharing circles discussions) with each all the six science teachers, to solicit teachers' views and perspectives on the integration of IK in science lessons. This baseline data will enable the researcher to answer research question 1. Afterwards least one teacher will teach a traditional lesson on waves and sound and another teacher will teach a traditional lesson on redox reactions.

2. This will be followed by three workshops.

Workshop 1:

This workshop will be the orientation workshop about the study and the roles of the participants. Additionally, clarity about the interviews and observations will be given.

Workshop 2-4: Two workshops on document analysis and two workshops on Lesson Studies (by the university lecturers who are also my critical friends) respectively will be conducted. Thereafter a workshop on reflective journals will be organised (Learners will be requested to read their journals to the teachers), and all workshops will be videotaped with the permission of the participants and the parents of the learners involved.

Phase 2

Document analysis identified science textbooks, grade 10- 12 Physical Sciences syllabus, Scheme of work, ATP, CAPS documents on the two topics: Waves and sound, and the redox reactions, examiners' report for the past five years-2017-2021, and at least the past three years end of year examinations (focusing on the two topics)

Workshop 5:

Teachers to reflect on workshops 1,2 &3. I observe and make suggestions.

Workshop 6

Workshop teachers on the TSPCK tool, to be used as a lens to analyse documents.

Phase: 3

A minimum of the three presentations will be conducted by expert community members. At this phase, data will be generated using participatory observation, videotape lessons and reflections (with the written permission of the participants).

Presentation 1: To be done by the two expert community elders who presented to the learners in my master's project, but this time around they will present to the teachers (they will focus on Indigenous cultural practices and beliefs related to the sea). The presentation will be done by the sea (out-of-school context), and the sea and fishing equipment will be used as a resource. A discussion session between the teachers and the expert community members might shed more light on this subject.

Presentation 2: I hope one of the mothers in our community will be keen to share her knowledge and IK of making bread. It is hoped that she will demonstrate how to make dough and explain the process from the IK point of view. The teachers will engage with her and hopefully identify key concepts in the topic of redox reactions. Teachers will be encouraged to write down their reflections about the presentations.

Presentation 3: I hope that I will find a willing Sangoma, from the township who will be able to share the cultural ritual and practices associated with the sea, with the teachers. An opportunity to discuss spirituality and African beliefs might stimulate a discussion, with the hope to get in-depth knowledge and learning through story telling.

Workshops 7 & 8

The presentations will be followed by workshops, wherein, teachers will be encouraged to read their reflective journals. Thereafter, we will all reflect in isiXhosa and in English and use language as a tool.

Phase: 4

After having completed the presentations, the PLC will reflect on the demonstration and explanation received from the community members and the document analysis. During this phase I will facilitate the way of integrating IK in science lessons, and we will co-develop model lessons on waves and sound, and redox reactions.

Phase: 5

After the co-development of model lesson plans that integrate IK, at least three science teachers will enact the lesson. Observation (videotaped lessons) and stimulated recall- interviews will be used to answer research question 4 using the TSPCK components for transformation of knowledge (Adapted from Mavhunga et al., 2016, pp. 312-313) see Appendix **G.**

This will be followed by group reflections.

Phase 6

Lastly, it is hoped that kitchen hands-on practical activity (on redox reactions) will be organised to assist teachers to mediate teaching and learning of the redox reactions.

APPENDIX E1: Semi-structured Interview Schedule

Research topic: Exploring using a Lesson Study approach when working with science teachers on how to integrate local IK to mediate learning.

What are the science teachers' experiences, pedagogical insights and attitudes towards the use of local or IK in science lessons?

Adapted from: (Cetin-Dindar and Geban, 2017 p, 89)

Questions	**Purpose**
1. Could you please tell me about your experience about teaching science?	To find out about their experiences of teaching science.
2. Could you please tell me what challenges you have been experiencing when teaching science?	To find out the challenges the teachers encounter when teaching the topic of waves and sound, and redox reactions with a view of alternative way of teaching.
3. Could you please tell me what your views are on the integration of local knowledge in science lessons?	To find out if teachers aware of using local knowledge in their science lessons.
4. Could you please give me an example of any topic in which you think you can integrate local knowledge?	To find out if teachers have an understanding of the topic in which they can integrate local knowledge.
5. Could you please tell me what the advantages are of integrating local knowledge in science lessons?	To find out if the teachers understand the value of integrating local knowledge in science lessons.
6. Could you please tell me what the disadvantages are of integrating local knowledge in science lessons?	To find out if the teachers understanding the challenges of integrating local knowledge in science lessons.

APPENDIX E2: Classroom Observation Schedule

Adapted from Nikodemus (2017)

	Notes
Organisation	
Teachers and learners are well prepared for the lesson	
Teacher have all necessary materials/resources and they are readily available	
Instructional	
Instructions used by the teacher	
Learning materials used by the teacher	
Time allocated to different learners in answering the questions	
Teachers responses to learners (IK integration)	

A teacher draws on non-participant learners in the lesson	
Teacher responses to questions asked	
Social interactions	
Learners' participation in the class	
Teachers' interaction with different learners	
Language usage	
Teacher uses appropriate and clear language	
Assessment	
Assessment used by teacher (questioning)	

APPENDIX F: Analytical Framework

Table 2: Analytical framework **(**Adapted from Atallah et al., 2010, p.48**)**

KEY CONCEPT	CONCEPTUAL FRAMEWORKS	RELATED PRACTICES (THE INDICATORS)
Integration of IK	**CONCEPTIONS**	**C1.** Describing what is the purpose of learning science.
		C2. Describing what they believe is required to learn science.
		C3. Describing the perceived value of integrating IK when learning science.
		C4. Describing what they believe indicates that have learned science during the presentations by the community members on IK and cultural practices about the sea and homemade bread.
	DISPOSITIONS	**D1.** Describing their ability in learning science during the integration of IK when teaching the topics on waves and sound and redox reactions.
		D2. Describing their attitudes towards learning science during the presentations by community members on IK and cultural practices about the sea.
		D3. Describing the learning approaches during the integration of IK when teaching the topics on waves and sound and redox reactions.
		D4. Describing their perceived value and evidence of learning science during the integration of IK when teaching the topics on waves and sound and redox reactions.

APPENDIX G: TSPCK Components

Table 2: Shows the TSPCK components for transformation of knowledge (Adapted from Mavhunga et al., 2016, pp. 312-313)

CONTENT-SPECIFIC COMPONENTS	INDICATORS
Learner prior knowledge	What learners already know and includes common misconceptions known in a topic.
Curricular saliency (CS)	Refers to the identification of the most important meaning of the major concepts in a topic, without which understanding of the topic would be difficult for learners. It also includes the knowledge to logically sequence the learning and the knowledge of pre-concepts needed prior to teaching a topic.
What is difficult to understand (WDU)	Refers to gatekeeping concepts which are difficult to understand often because they cause conflict with previously established understanding.
Representations (RP)	Refers to a combination of representations at *macro*, *symbol* and *sub-microscopic* levels that may be employed to support an explanation. Example, illustrations, metaphors, analogies, models, stimulations.
Conceptual teaching strategies	Refers to teaching strategies derived from the considerations made from the other components e.g. (particular misconception, and particular educational purpose). It excludes general teaching methodologies.

APPENDIX H: Five Cognitive States

Table: 3 Shows Five cognitive states from Ogunniyi's (2007a, P.971) CAT as Analytical framework

No:	The five cognitive states	Indicators
1	Dominant	▪ The most prevalent worldview being mobilised to solve the problem in a given context.
2	Suppressed	▪ Able to identify worldview that is suppressed by the more dominant one.
3	Assimilated	▪ The worldview that is suppressed by the more dominant one ▪ The idea assimilated into another more adaptable conception.
4	Emergent	▪ The worldview that develops from a new experience, e.g., the acquisition of a new concept in a science class ▪ What arises when Grade 10 Physics leaners have no previous knowledge of a given concept of waves and sound and redox reactions.
5	Equipollent	▪ Two powerful worldviews exerting equal cognitive force on a person's worldview ▪ In this conception might be able to see the competing ideas tend to co-exist in the science teachers as an emotional arousal experienced by community members during the *presentations about IK related to the sea and homemade bread.*

APPENDIX I: Concepts of SCT

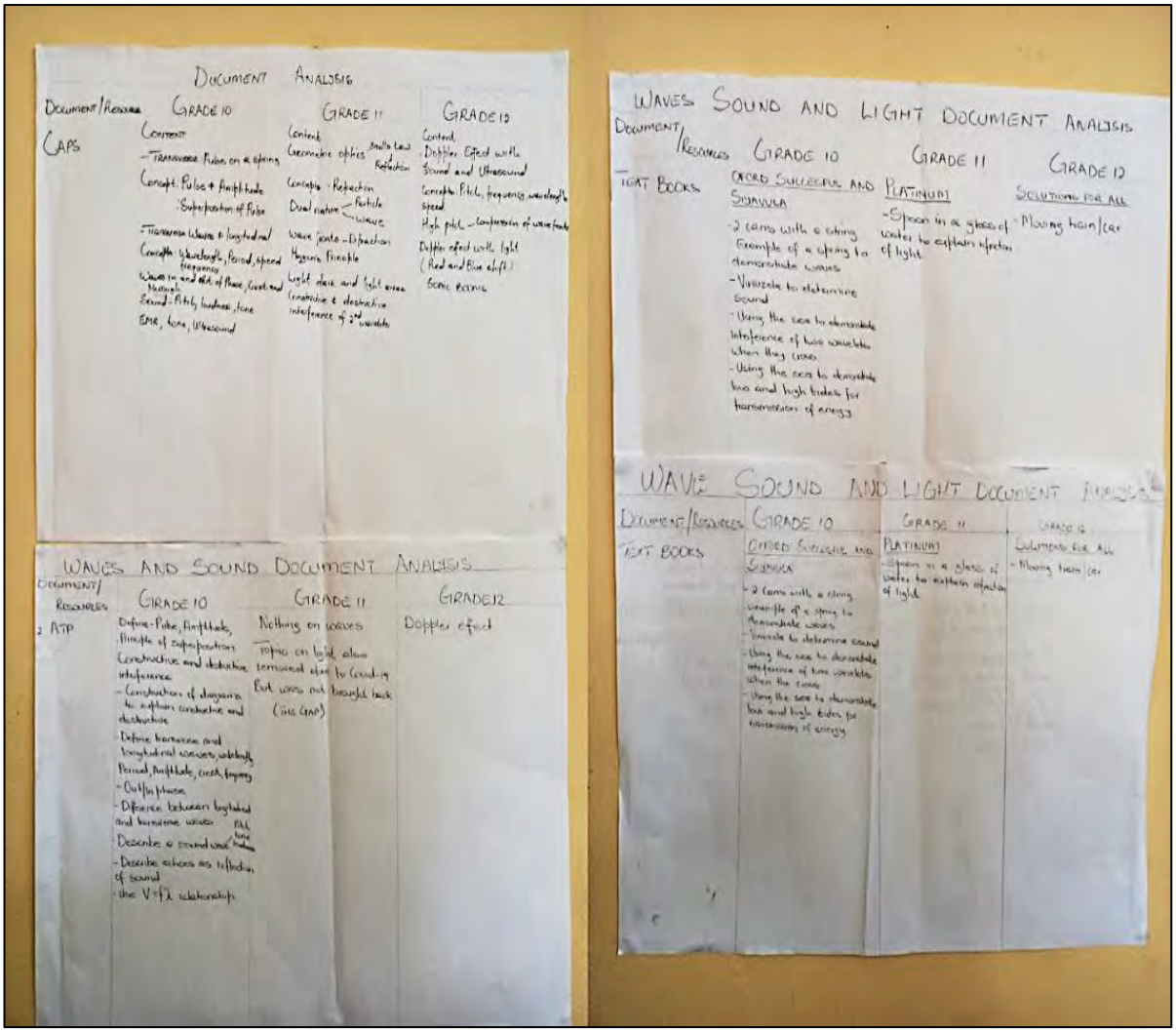
Table: 4 Shows the concepts within SCT (Vygotsky, 1978) theoretical framework

Exploring using a Lesson Study approach when working with science teachers on how to integrate local IK to mediate learning.

No:	Concepts within SCT	What to look for?
1	Social interactions	• Involvement, absorption, focused effort, and through the research process. • Effective reflections when participating in the PLC and the demonstration and explanation of community members about cultural practices and beliefs related to the sea (waves and sound) and IK about making bread and redox reactions.
2	Mediation of learning	• Teachers to move learners from the known knowledge to unknown using artefacts • Viewing learning process under a learner-centred skill which supports the social constructivist perspective.
3	Language	• I observed the interactions and engagements between the teachers and the expert community members, paying particular attention to the use of language, in particular isiXhosa, as a cultural tool. According to Vygotsky (1978), language plays a crucial role in fostering learning.
4	Culture	• I observed the use of language (isiXhosa and English) and cultural practices during the presentations by the expert community members.
5	ZPD	• Through its affirmation that what one can do today with assistance is indicative of what one will be able to do independently in the future.

APPENDIX J: Document Analysis

Figure 6.7: Showing news prints of data analysis



APPENDIX K: Hands-on Practical Activities Workshop

Worksheet on hands-on practical activities using easily accessible resources

RHODES UNIVERSITY

DEPARTMENT OF CHEMISTRY

Practical work with Science teachers

Exothermic and Endothermic Reactions

When chemicals are mixed together in a chemical reaction, they can either give off heat or they can absorb heat.

A chemical reaction that is accompanied by the **release of heat** (gets hotter) is called an e**xothermic** reaction. **ΔH is negative**, but it can also release energy in form of light (e.g. explosions), sound or electricity (e.g. a battery). When we perform an exothermic reaction in a flask, it initially warms.

A chemical reaction that is accompanied by the **absorption of heat** (gets colder) is called an e**ndothermic** reaction. **ΔH is positive**.

You will perform the following experiments, and answer the accompanying questions.

1. Melting ice

Equipment needed: Ice, thermometer, cup or beaker.

Half fill the cup with water, then stir in some ice and observe the temperature changes.

Questions:

How did the temperature change? …….

Is this a physical or a chemical change? ……..

Is this reaction endothermic or exothermic? ……..

What is the sign of ΔH? ……

2. Sodium hydroxide and water

Measure out 20ml of water into the beaker

Place a thermometer into the water, measure and record the temperature.

Add ¼ teaspoon of caustic soda (sodium hydroxide, NaOH, from the supermarket) to the water.

Stir the solution for five minutes.

Measure and record the temperature of the solution.

Questions:

How did the temperature change? …….

Is this reaction endothermic or exothermic? ……..

What is the sign of ΔH? ……

3. Reaction between sodium bicarbonate and citric acid

Equipment needed:

- Sodium hydrogen carbonate ($NaHCO_3$) (also called sodium bicarbonate, bicarbonate of soda or baking soda – you can get this from a supermarket)
- Citric acid ($H_3C_6H_5O_7$) (you can get this from a supermarket)

Method:

Place one teaspoon (5g) of sodium hydrogen carbonate in the beaker.

Add about 50 mL of water and stir to dissolve the sodium hydrogen carbonate.

Place the thermometer in the solution and record the temperature of the solution.

Then add half a teaspoon (2.5g) of citric acid and stir with the glass rod.

Record the temperature every 30 seconds for five min.

The reaction is $H_3C_6H_5O_{7(s)} + 3NaHCO_{3(aq)} \rightarrow 3\ CO_{2(g)} + 3\ H_2O_{(l)} + Na_3C_6H_5O_{7(aq)}$

The reaction is a neutralisation reaction between an acid (the citric acid) and a base (the sodium hydrogen carbonate). Carbon dioxide gas is given off and water and sodium citrate are formed.

Questions:

How did the temperature change? …….

Is this a physical or a chemical change? ……..

Is this reaction endothermic or exothermic? ……..

What is the sign of ΔH? ……

4. Sulphuric Acid into Water

Safety Hazard: Concentrated sulphuric acid is extremely corrosive. The reaction can be violent. Wear safety goggles and disposable gloves. Add acid to water **SLOWLY**

Method:

Add 20 mL of water into beaker.

Take initial temperature reading.

SLOWLY add about 7ml of **ACID TO WATER**.

Take temperature again.

Questions:

How did the temperature change? …….

Is this reaction endothermic or exothermic? ……..

What is the sign of ΔH? ……

5. Evaporation of Acetone

Place a few drops of acetone on the back of your hand and feel the effect as the acetone evaporates. Heat from your body is used to break the intermolecular bonds between the acetone molecules as it changes from a liquid to a gas.

Questions:

Is this a physical or a chemical change? ……..

Is this reaction endothermic or exothermic? ……..

What is the sign of ΔH? ……

6. Rusting Iron

In this reaction vinegar is used to remove the protective coating from steel wool, allowing it to rust. Then the iron combines with oxygen to form rust: $Fe(s) + O_2(g) \rightarrow Fe_3O_2(s)$

Method:

1. Soak a piece of steel wool in vinegar for 1 minute.
2. Squeeze the excess vinegar out of the steel wool.
3. Wrap the wool around the thermometer and place the wool/thermometer in the beaker.
4. Record the temperature.
5. Allow 5 minutes, then read the temperature again, and compare it with the first reading.

Questions:

How did the temperature change? …….

Is this a physical or a chemical change? ……..

Is this reaction endothermic or exothermic? ……..

What is the sign of ΔH? ……

7. Sulphuric Acid and Sugar DEMONSTRATION (this will be demonstrated, you may NOT attempt this experiment)

Method:

Put ordinary table sugar in a glass beaker and stir in some concentrated sulphuric acid (you can dampen the sugar with a small volume of water before adding the sulphuric acid) and observe. This is a dehydration reaction – the water is removed from the sugar:

$C_{12}H_{22}O_{11}$(sugar) + H_2SO_4(sulphuric acid) → 12C + 11H_2O (water) + mixture water and acid + $SO_2(g)$

Questions:

Is this a physical or a chemical change? ……..

Is this reaction endothermic or exothermic? ……..

What is the sign of ΔH? ……

_____END OF WORKSHEET_____

APPENDIX L: Data Analysis of MaMcirha's Presentation from Teachers' Reflections

teachers' reflections show that four themes emerged during MaMcirha's presentation

MaMhegeba said that:

"This was an eye-catching, interesting, practical and clear presentation"

"Indigenous knowledge which has become a true reflection of science"

"Ingredients, measurements, chemical reactions, procedure of making dough were clearly presented"

"Mixtures were one of the main topics as we use mixtures in our daily lives"

"The presentation showed a clear link between IK and science"

"MaMcirha explained measurements without using any measuring cylinders and they were accurate"

"Reactions were also explained by MaMcirha that she used used lukewarm to speed up the reaction"

"Ingredients mixed in a correct way there was no more no less that would result in the dough not to be ready to be baked"

"This presentation also taught me to respect all people and not look at people on the jacket"

"How I so wish to use MaMcirha in my own teaching practice which will need indigenous knowledge"

MaMpehle indicated that:

"MaMcirha did not have any measuring tool to measure anything, she knew how much she will use all for her dough"

"She explained that she used lukewarm water because hot water will burn the dry yeast and the dough will not rise, because the yeast will be destroyed"

"MaMcirha mixed everything and covered the dough using plastics and a cloth to keep the dough warm so that it could rise"

"The session was very interesting, I learned a lot, for example I knew that I had to use lukewarm water but I did not know the reason for that"

"I also learned that covering the dough is so important because it gives it warmth to be able to rise easy, I enjoyed the session"

Mangconde highlighted that:

"The presentation by MaMcirha was very interesting"

"I have learned the measurements of ingredients without using measuring instruments"

"The presentation was very interesting such that it gave me more ideas to teach reactions in my science class using IK"

MaMyeka said that:

"I was looking forward to MaMcirha's presentation of bread making because I have stopped making homemade bread because it either become damp or has too much yeast that smells"

"She first washed her hands before handling food, that left a great impression to me because cleanliness is next to Godlines"

"MaMcirha did not have the measuring tools but she new the exact quantities that she must add, this was my first mistake, I did not know the measurements"

"My second mistake was to use hot water instead of lukewarm water"

"Another thing that impressed me was when she cooked and the water run out before the bread was properly cooked she added water to maintain the equilibrium, she explained that if she added cold water the bread will be damp as she would have disturbed the equilibrium"

"Someone who has little education, a cleaner at school but possesses great and detailed knowledge passed on to her by her mother, the power of indigenous knowledge. She is passing that knowledge on to her daughters".

Zizi commented that:

"I had an opportunity to be part of the presentation done by MaMcirha. All I can say is that the amount of knowledge that MaMcirha has is so amazing, and her confidence to present to the teachers is unbelievable, she did a great presentation"

"I have learned so much from MaMcirha, I think I can now confidently try to make the homemade bread or teach others"

"What I enjoyed the most was that MaMcirha explained everything without being asked why, I think as a teacher I have learned a new teaching approach"

"Ndingathi in closing ubukho buka MaMcirha bube lulutho kakhulu kwaye sifunde likhulu kuye."

"Mna ndifunde ukuba umntu xa umjonga you don't have to focus on one aspect like academic achievement nelicala lemveli kufuneka singalibekeli kude. Ulwazi lwakhe nam lundikhulisile, ndiyabulela"

Madiba said that:

"I found the presentation very interesting, clear and informative"

"The amount of IK that was used to explain difficult science concepts was just great and the way why we use this and that"

"I have learned a better approach to explain Le Chartellir's Principle and rates of chemical reactions and I could use IK in other topics, I just need to research and prepare"

"The is no doubt in my mind that we need IK and elders to help us in science, so I would say we need to invite even bush mechanics to explain topics like AC and DC motor"

Mangconde said that:

"The presentation of making dough by MaMcirha was very interesting"

“She used the ingrediaents without the measuring utensils, but she knows the measurements from experience”

“The presentation was very interesting in such that it gave me more ideas to teach reactions in my science class using IK”

“I have seen how IK was used during the demonstration, I have learned how to use IK in science, and I will try and integrate IK in other science topics, it helps to explain difficult science concepts”

APPENDIX M: Themes and Sub-themes From Sharing Circle

Sub-themes and themes that emerged from the sharing circles discussions base on RQ1

RQ1: What are Science teachers' perspectives and pedagogical insights on the integration of IK in their teaching before the intervention?		
Sub-themes	**Themes**	**Literature/Theory**
…were used to doing practical activities (Ndlovu) at school there is a lack of laboratory (Ndlovu) …through my own research I use cabbage water as an indicator. (MaMhegeba) When you research in science you always find new knowledge in science. (MaMhegeba) …when they are working with their hands.(MaMpehle) they will see the practicality of what you are talking about (MaMyeka) make practical examples for instance of boiling water (MaMyeka) zenze zibe yi reality bazibone (practical demonstration). (MaMyeka)	Use of hands-on practical activities	Asheela et al. (2021); Shinana et al. (2021); Vygosky (1978)

science is a practical subject (MaNgconde) coffee for conduction the learner had to hold it and the heat was transferred (MaMhegeba) I saw Indigenous elders melting a metal in an oven to make a bowl.(Ndlovu) Science in the homes of children is everyday practice (MaMyeka)		
learners also have a challenge of language, most learners are not equipped with the language in science. (Ndlovu) they understand there is a language barrier (MaMhegeba) they understand there is a language barrier (MaMyeka) has to make a link between this foreign language English which is a foreign language to them (MaMyeka) its only that you add these English concepts (MaMyeka)	Language as a challenge	Chilisa (2012) Vygotsky (1978)

so you have to make a language switch from English to IsiXhosa.(MaMhegeba) …you then bring in code-switching (MaMyeka) Umcacisele ngesiXhosa (MaMpehle)	Using code-switching as a mediation tool	
learners watch a video (MaNgconde) I introduced my IT skills (Madiba) I downloaded videos (Madiba)	Using IT as an enabling tool	
compare science to local knowledge you find that it is something interesting (Zizi) if you talk about making bread they see their mothers preparing all the ingredients (MaMyeka) you start with a known to the unknown.(Zizi) prior knowledge gives the teacher a chance to build on. (Mangconde) It is very important to reflect on learner prior knowledge, (Ndlovu)	Soliciting learner's prior knowledge	Aikenhead and Jegede (1999) Roschelle (1995)

you figure the standard knowledge of a learner. (Ndlovu) So, to figure out the learners' prior knowledge is very important.(Ndlovu) must figure out the learner's prior knowledge and from there you introduce science concepts. (Ndlovu) the learners come to school with knowledge from home, but if I as a teacher I don't interact with the learners,(MaMhegeba) some teachers will just teach what is in front of them ignoring the fact that these learners have knowledge. (MaMyeka)		
more research must be done before we take some of the Indigenous ways of living. (MaMhegeba) There is some confusion when it comes to indigenous knowledge, (MaMhegeba) I also believe that if the elders could come and teach us that would help a lot. (MaMyeka) knowledge in Africa throughout has been build on IK (Ndlovu) In Africa we were living on IK and never had any problems, the colonisers came and	Science teachers' perceptions towards the integration of IK in science teaching	Snively and Williams, (2008) Gwekere (2016) Aikenhead and Jegede (1999)

forced them to use a certain education type, they created a barrier. (Ndlovu) I can say if you bring in IK science in Africa will move in a faster pace. (Ndlovu) NO there is no disadvantage of integrating IK in science. (Ndlovu) we need to go to those old people who would tell us about those plants. (MaMhegeba) The young kids in Foundation Phase would be keen to know more and engage their parents at home (MaMpehle) is advantageous to talk about IK in science in order to save lives and clear misconceptions.(MaMhegeba) I suggest that we invite those elders to come and teach us about Indigenous ways (MaMhegeba) using our daily experiences and incorporate it into science teaching. (Ndlovu) Bringing in IK will help learners pay more attention to little things. (Mangconde)		

Endothermic and Exothermic reactions. (Ndlovu) That would be in redox reactions (MaNgconde) In lightning (Zizi) Fertilizer (MaMhegeba) chicken manure used as a fertilezer (MaNgconde) Conduction. (Zizi)	IK in Specific Topics in science	Mavhunga and Rollnick (2013) Shulman (1986)