

**Revitalisation and indigenisation of the Science curriculum through
drum making, drumming, music and dance**

A thesis submitted in fulfilment of the requirements for the degree

Of

Doctor of Philosophy

(Science Education)

In the

Education Department

Rhodes University

By

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June 2022

Declaration

I, **Angelius Kanyanga Liveve (15L7775)** declare that the work contained in this thesis is my original work. It has not been previously submitted in any form for assessment or degree in any other higher education institution. All ideas, quotations, and other materials used in this study that were derived from the work of other people have been indicted in the list of references.

Signature:



Date: June 2022

Dedication

I dedicate my thesis work to my family and friends. A special word of gratitude to my loving wife, Veronika Makena whose words of encouragement and push for persistence ring in my ears and have never left my side. To my children, this is my voice you can hear when reading this thesis.

I also dedicate this thesis to my friends and classmates who have supported me throughout the process. I will always appreciate all that they have done, especially the Mayor of Nkurenkuru Town Hon Cllr Erastus Sientu Kandjimi for being compassionate with my workload.

Acknowledgements

First and foremost, praises and thanks to God, the Almighty, for His showers of blessings throughout my research work to complete the research successfully. I would like to express my deep and sincere gratitude to my research principal supervisor Professor Kenneth Ngcoza and the co-supervisor Dr Nhase for allowing me to do research and providing valuable guidance throughout this research. Your dynamism, vision, sincerity, and motivations have deeply inspired me. You have taught me the methods to conduct research and to present the research works as clearly as possible. It was a great privilege and honour to work and study under your guidance. You all provided insightful comments and hard questions that prompted me to widen my perspective and consider modifications for the smooth flow of my writing.

Similarly, I am grateful to Dr Mukwambo for his voluntary work in facilitating workshops on the integration of indigenous knowledge (IK) with the Science lessons. I also acknowledge the help and engagement of the Unongo Youth Cultural Group who are the custodians of the cultural knowledge *of drum making, drumming, music and dance*, and for their demonstrations and explanations without which it would not have been possible to yield rich data for this research.

I would also like to thank the Grade 10 Physics teachers of the Kandjimi Circuit of Kavango West Region of Namibia in 2020 who participated in this research. You have willingly shared your precious time in the process of interviews, taking part in the participatory observations during the demonstration and explanations of the *drum making, drumming, and music and dance* by community members, your participation in all workshops organised during this study, and all your lessons. Your participation resulted in the study having an astounding outcome.

Finally, to my caring, loving, and supportive wife, Veronika Makena Liveve (Mrs.), receive my deepest gratitude. Your encouragement when the times got rough is much appreciated and duly noted. It was a great comfort and relief to see you manage the household activities and particularly during the difficult situation of our daughter, Hildegard Kasiku Tulinendi Liveve while I

completed my work. May you receive my heartfelt gratitude! May God bless you all *Kalunga ami vzhikithe*.

To my family of Rhodes Masters and PhDs candidates for both Namibian and South African programs, thanks for the motivating discussions and the fun we had. It was amazing to have friends like you in this ‘thorns and bushes’ journey.

Special thanks to my best friend Fredrick Simata Simasiku for helping me develop my technology skills and my wonderful sons (Hegel-Ndala yange & Joakim- ‘Kim’) and daughters (‘Kuku’Ndambu & Hildegard Kasiku Tulinendi) for being there for me throughout the entire doctoral journey. So, you and your mother have been my best cheerleaders.

I would also like to extend my sincere words of gratitude to Dr Mashiri and Dr Mutanho for finding time to cast their critical eyes and commenting on my thesis.

Finally, I would like to extend my sincere words of gratitude to Ms. Nikki Watkins for professionally formatting and editing my thesis. God bless you!

Abstract

The integration of IK is a common phenomenon in many postcolonial states, where it is viewed as a means to redress the injustices of the colonial era. It is believed that the recognition of IK in education represents an acknowledgement of diversity and other ways of knowing. In Namibia, for instance, the National Curriculum for Basic Education encourages the integration of IK in Science teaching. However, this goal is still far from being achieved because the curriculum seems to be silent on how teachers should integrate IK into their teaching. As a result, research shows that many Science teachers in Namibia seem to find it difficult to integrate IK into their science teaching because they were not properly trained to do so during both their pre-service and in-service training. This suggests that there is a dire need to empower science teachers who are implementers of the curriculum on appropriate pedagogical content knowledge on how to integrate IK into their science teaching in particular. It is against this backdrop that this interventionist study sought to explore how to mobilise the indigenous technology of *drum making, drumming, music and dance* for cultural revitalisation and indigenisation of the science curriculum.

The study is underpinned by an interpretivist paradigm and augmented with an indigenous research paradigm. The interpretivist paradigm enabled me to understand the teachers' perspectives in their contexts. On the other hand, within the indigenous research paradigm, I used the Ubuntu perspective which afforded each of us an opportunity to understand each other's ways of knowing, doing and being. Within these two complementary paradigms, a qualitative case study approach was employed. The case study was in the form of intervention with six Grade 10 Physics teachers from three senior secondary schools in the Kavango West Region in Namibia. Moreover, a critical friend who was a lecturer at the university and expert community members of the Unongo Cultural Youth Group who are the custodians of the cultural heritage. Data were generated using semi-structured interviews, workshop discussions (audio-recorded), observations (participatory and lesson observations), stimulated recall interviews as well as journal reflections. Vygotsky's Socio-cultural Theory, Ogunniyi's Contiguity Argumentation Theory and Mavhunga and Rollnick's Topic-specific Pedagogical Content Knowledge were used as the theoretical lenses in this study. The data gathered were analysed thematically and then categorised into sub-themes and themes.

The findings of the study revealed that tapping into the cultural heritage of community members through giving them a *voice* has great potential to revitalise and indigenise the science curriculum. It also emerged in this study that *storytelling* is a potential instructional strategy to make science accessible and relevant to learners. The use of the indigenous technology of *drum making, drumming, music* and *dance* contributed to the Physics teachers' agency and empowered them to co-develop their learning and teaching support materials in the form of exemplar lesson plans that integrated IK. Moreover, their pedagogical content knowledge was enhanced through enacting such exemplar lessons and thereafter reflecting on them.

The study thus recommends that those in academia should promote the use of indigenous technologies as hubs for mediating the learning of science concepts. It also recommends that learners should be taken out of their science classrooms into the community to learn IK and wisdom from expert community members, something which could assist them in understanding the science taught at school. This might also benefit teachers in effectively implementing the integration of IK in schools and thereby use learners' cultural heritage as a starting point to enrich meaningful and authentic learning.

Keywords: Physics, Drum Making, Drumming, Music, Sound, Indigenous Knowledge, Professional Community of Learning, Socio-cultural Theory, Contiguity Argumentation Theory, Topic-specific Pedagogical Content Knowledge

TABLE OF CONTENTS

Declaration	ii
Dedication	iii
Acknowledgements	iv
Abstract	vi
List of Figures	xviii
List of Tables	xxii
List of Abbreviations and/or Acronyms	xxiii
Translation of Concepts	xxv
CHAPTER ONE: SITUATING THE STUDY	1
1.1 Introduction	1
1.2 Background of the Study.....	2
1.3 My Personal Life Story – Situating Myself in the Study	3
1.4 My Positionality and Reflexivity	9
1.5 The Statement of the Problem.....	11
1.6 Purpose and the Significance of the Study.....	13
1.7 Research Goal and Research Questions	13
1.7.1 Research goal.....	13
1.7.2 Research questions	13
1.8 Theoretical Frameworks.....	14
1.8.1 Socio-cultural theory	14
1.8.2 Contiguity Argumentative Theory	14

1.9 Data Gathering Methods	15
1.10 Definition of Terms	15
1.11 Thesis Outline	18
1.12 Chapter Summary.....	20
CHAPTER TWO: LITERATURE SYNTHESIS.....	21
2.1 Introduction	21
2.2 Namibian Curriculum.....	21
2.3 Hands-on Physics Practical Activities and Visualisation.....	23
2.4 Understanding Indigenous Knowledge	24
2.4.1 What does indigenous mean?	25
2.4.2 What is knowledge?.....	28
2.4.3 What is indigenous knowledge (IK)?	30
2.4.4 What is an indigenous knowledge system (IKS)?	32
2.5 Indigenous Knowledge in Sound Production.....	32
2.5.1 Traditional wooden drum – Ngoma	33
2.5.2 Northern Namibian musical instruments.....	37
2.5.3 Storytelling	38
2.6 Implications for My Study	39
2.7 The Nature of Indigenous Knowledge	40
2.8 Nature of Western Science.....	43
2.9 Worldview.....	44
2.9.1 The concept of worldview	44
2.9.2 Worldview and teaching.....	47
2.10 The IK Perspective on Physics Teaching.....	53

2.11 Indigenous Knowledge in the National Curriculum for Basic Education.....	54
2.11.1 Sound waves and echo.....	56
2.11.2 The physics of sound.....	57
2.11.3 Loudness and softness of the sound.....	58
2.12 Challenges of integrating IK.....	58
2.13 Physics Teachers’ Professional Learning Community.....	60
2.14 Pedagogical Content Knowledge.....	66
2.15 Chapter Summary.....	70
CHAPTER THREE: THEORETICAL FRAMEWORKS.....	71
3.1 Introduction.....	71
3.2 Vygotsky’s Socio-Cultural Theory.....	71
3.2.1 Mediation of learning.....	72
3.2.2 Culture and language.....	73
3.2.3 Social interactions.....	75
3.2.4 Zone of Proximal Development (ZPD).....	76
3.2.5 Self-regulated learning.....	77
3.3 Ogunniyi’s Contiguity Argumentative Theory.....	79
3.4 Chapter Summary.....	81
CHAPTER FOUR: RESEARCH METHODOLOGY.....	82
4.1 Introduction.....	82
4.2 Research Paradigms.....	82
4.2.1 Interpretivist paradigm.....	83
4.2.2 Indigenous research paradigm.....	84
4.3 Research Design.....	89

4.3.1 Qualitative case study.....	90
4.3.2 Research goal and questions.....	95
4.3.3 Research site and selection of participants.....	95
4.3.3.1 VaUkwangali identity through dance	97
4.3.3.2 Unongo Cultural Youth Group: The ECMs.....	101
4.3.3.3 Teacher participants.....	102
4.4 Data Gathering Methods	103
4.4.1 Interviews	104
4.4.1.1 Semi-structured interviews	104
4.4.1.2 Stimulated recall interviews.....	105
4.4.2 Observations	106
4.4.2.1 Participatory observation	107
4.4.2.2 Lesson observations.....	108
4.4.3 Reflective journals.....	109
4.5 Research Process	111
4.5.1 Phases of the research.....	111
4.5.2 Negotiating access	113
4.5.3 COVID-19 preventative measures during workshops.....	114
4.6 Validity and Trustworthiness	115
4.7 Ethical Considerations.....	118
4.8 Chapter Summary.....	119
CHAPTER FIVE: SEMI-STRUCTURED INTERVIEWS.....	120
5.1 Introduction.....	120
5.2 Development of Themes for this Research Question.....	121

5.2.1 Teachers' views on the use of indigenous knowledge in science teaching	126
5.2.2 Teachers' understanding of curriculum and indigenous knowledge	128
5.2.3 Teaching science by using cultural artefacts	131
5.2.4 Hands-on practical activities in science lessons	132
5.3 Challenges in Integrating IK with School Knowledge.....	134
5.4 Chapter Summary.....	134
 CHAPTER SIX: PARTICIPATORY OBSERVATION AND STIMULATED RECALL	
INTERVIEWS 135	
6.1 Introduction	135
6.2 Knowledge in Ukwangali.....	136
6.2.1 Language	136
6.2.2 Cultural technologies	137
6.2.3 Practical skills.....	138
6.3 Data from the ECMs During Drum Making	140
6.3.1 Carving of musical instruments: Ngoma	141
6.3.2 Tanning skin for drumhead	146
6.4 The Physics of a Drum	149
6.4.1 Explanations from ECMs on the size of the drum hollow and shell	150
6.4.2 Explanations from ECMs on thickness and thinness of the skin.....	151
6.4.3 Explanations from ECMs on the type of skin used in wrapping the hollow	153
6.5 Data from the ECMs During Drumming, Music, and Dance.....	153
6.5.1 Drumming techniques.....	154
6.5.2 Traditional music and dance.....	156

6.5.3 Data that emerged during demonstrations and explanations of traditional music and dances: <i>Epera</i>	161
6.6 Data from the Grade 10 Physics Teachers During Drumming, Music and Dance	163
6.7 Gender and Unongo Youth Cultural Group	168
6.8 Summary of Findings	168
6.9 Chapter Summary.....	169
CHAPTER SEVEN: CO-DEVELOPMENT OF EXEMPLAR LESSONS, DISCUSSIONS AND REFLECTIONS	171
7.1 Introduction	171
7.2 Indigenous Knowledge and Physics from the Ukwangali Community	172
7.2.1 Data from teacher discussions and reflections	172
7.2.2 Grade 10 Physics textbooks.....	175
7.2.3 Field notes	176
7.2.4 Past examination papers for Grade 10 Physical Science.....	176
7.3 Data that Emerged from Mburu and Lyako During the Co-developed Exemplar Lesson One	177
7.4 Data that Emerged from Mburu and Lyako During the Co-Developed Exemplar Lesson Two.....	179
7.5 Data that Emerged from Kondjereni and Kaurungi During the Co-Developed Exemplar Lesson Two	181
7.6 Data that Emerged from Nda-Kulanda and Kambinda During the Co-Developed Exemplar Lesson One.....	184
7.7 Data that Emerged from Nda-Kulanda and Kambinda During the Co-Developed Exemplar Lesson Two	185
7.8 Summary of Findings	186

7.9 Chapter Summary.....	192
CHAPTER EIGHT: INTEGRATION OF INDIGENOUS KNOWLEDGE IN THE OBSERVED LESSONS	194
8.1 Introduction.....	194
8.2 The School and Classroom Context.....	196
8.2.1 Kaurungi.....	196
8.2.2 Lyato.....	197
8.2.3 Mburu.....	198
8.3 Mediation of Learning in the Co-developed Exemplar Lessons.....	199
8.3.1 Analysis of Kaurungi’s observed lessons.....	199
8.3.2 Analysis of Lyako’s observed lessons.....	205
8.3.3 Analysis of Mburu’s observed lessons.....	208
8.4 Emerged Themes of the Observed Lessons.....	210
8.4.1 Culture of learning and materials.....	211
8.4.2 Learners’ prior knowledge.....	212
8.4.3 Representations and visualisations.....	212
8.5 Discussions of Findings of the Observed Lessons.....	212
8.6 Participants’ Experiences and Benefits.....	213
8.6.1 Expert community members.....	214
8.6.2 Grade 10 Physics teachers.....	215
8.7 Chapter Summary.....	217
CHAPTER NINE: SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSIONS 218	
9.1 Introduction.....	218

9.2 Overview of the Study.....	219
9.3 Summary of Findings	220
9.3.1 Research question 1	220
9.3.2 Research question 2	221
9.3.3 Research question 3	222
9.3.4 Research question 4.....	223
9.4 New Knowledge.....	223
9.5 Limitations of the Study.....	225
9.6 My Reflections	226
9.7 Conclusion.....	227
9.8 Recommendations	228
References	230
Appendices.....	273
Appendix A: Research Ethics clearance	273
Appendix B: Permission letter to the Director	274
Appendix C: Response from the office of the Director	277
Appendix D: Permission letter to the knowledgeable community member/s on drum making, drumming, and dance	278
Appendix E: Semi-structured interview schedule.....	280
Appendix F: Teacher’s profile	281
Appendix G: Indicators for teachers’ conceptions and dispositions (Atallah et al., 2010, p. 48)	282
Appendix H: TSPCK components for transformation of knowledge (adapted from Mavhunga & Rollnick, 2016, pp. 312-313)	283

Appendix I: Themes emerging from semi-structured interviews.....	284
Appendix J: CoP Adapted from Wenger (2011, p 3).....	287
Appendix K: Themes emerging from semi-structured interviews and discussions during document analysis workshop with cognitive states.....	288
Appendix L: Teachers’ views toward the use of indigenous knowledge in science lessons ..	289
Appendix M: Teachers’ understanding of curriculum and indigenous knowledge	291
Appendix N: Teaching science using cultural artefacts	291
Appendix O: Cultural practices which could support teaching and learning of science concepts	292
Appendix P: Teachers’ responses regarding practical activities in science lessons	294
Appendix Q: Five cognitive states of CAT (Ogunniyi 2007a)	295
Appendix R: Temperature record for the participants during workshops in phase 2	298
Appendix S: Traditional music instruments.....	299
Appendix T: Traditional dances in the local community	300
Appendix U: Scheme of assessment for grade 10 and 11	302
Appendix V: Grade 10 Physics teachers’ analysis of past exam papers about IK during co-developed exemplar lessons	303
Appendix W: Summary of the observed topics and indigenous technologies.....	309
Appendix X: Analytical framework for CAT	310
Appendix Y: TSPCK of the analytical framework (adapted from Mavhunga & Rollnick, 2017)	312
Appendix Z: Sample TSPCK MAPs for observed developed TSPCK component interactions (Adapted from Mavhunga, 2020).....	315
Appendix AA: Statement Agreement for Mr. Neporo to use his real name	317
Appendix BB: Collated semi-structured interview data	318

List of Figures

Figure 2.1: Drums, drumming, music and dances (Liveve, 2017, p. 68)	34
Figure 2.2: Characteristics of IK for community development (https://e76f7d1a-a-62cb3a1a-sites.googlegroups.com)	42
Figure 2.3: Qualities associated with traditional knowledge system and Western science (Barnhardt & Kawagley, 2005, p. 16).....	48
Figure 2.4: Components of social theory: An initial inventory (Wenger, 1998, p. 5).....	61
Figure 2.5: Dimensions of practice in professional learning community (adapted from Chauraya & Brodie, 2018, p. 2)	62
Figure 2.6: Three component of a community of practice (Noll & Beecham, 2019, p. 2).....	63
Figure 2.7: Teacher professional knowledge (Neumann et al., 2019, p. 849).....	66
Figure 2.8: A model for TSPCK (Mavhunga & Rollnick, 2013, p. 115)	68
Figure 4.1: Research design connects the research questions to data (adapted from Punch & Oancea, 2014, p. 142)	89
Figure 4.2: Shows the DAIM (adapted from Langenhoven & Stone, 2013, p. 5).....	93
Figure 4.3: Learning process of integrating IK in science (adapted from Chikamori et al., 2019, p. 9)	94
Figure 4.4: The map of the Kavango West region with the Tondoro constituency where the study occurs (adapted from https://r.search.yahoo.com/).....	96
Figure 4.5: A tippy tap mounted at the public area of Nkurenkuru veterinary rural extension.	115
Figure 4.6: Data validation through talking circles (Chilisa, 2012)	117

Figure 5.1: Steps followed for qualitative analysis of data involving seven Grade 10 Physics teachers in semi-structured interviews (adopted from Nandini et al., 2022, p. 149)	122
Figure 6.1: MpasiNkuru Auction Pan for the VaUkwangali community	138
Figure 6.2: Women weaving grass.....	139
Figure 6.3: Trunk from a Mangetti tree being perforated for a drum - <i>Ngoma</i>	141
Figure 6.4: The head (hollow side) of the drum	142
Figure 6.5: Hexagon chisel (<i>Etwiso</i>).....	143
Figure 6.6: Preparing the drumhead membrane.....	145
Figure 6.7: Using bradawl- <i>Munho</i> to drill a hole for pegging.....	146
Figure 6.8: Making tanned raw animal skin by soaking in water with salt or wood ash.....	147
Figure 6.9: Shaving the skin after being mounted over a drumhead	148
Figure 6.10: The shaved skin around the drumhead.....	149
Figure 6.11: Transmission of sound from the source (https://www.ccohs.ca/oshanswers/phys_agents/noise/_basic.html#figure1)	150
Figure 6.12: Shows two drums with different diameters (https://r.search.yahoo.com)	151
Figure 6.13: Wax (<i>Enongo</i>) for altering the pitch.....	152
Figure 6.14: Shows palm position for bass.....	155
Figure 6.15: Shows palm position for open, closed slap and for finger open tone.....	156
Figure 6.16: Traditional music and dances performed by Unongo Youth Cultural Group	157
Figure 6.17: An expert community member in the cultural attire	162

Figure 6.18: Represents dancers and combo of three drums played for the epera dance (https://r.search.yahoo.com).....	163
Figure 6.19: Heating skin to alter the tune of a drum through thermal radiation	165
Figure 7.1: Shows the dispersal of white light to form all the colours of the rainbow (https://images.app.goo.gl/jSzXWEJxYCxB1fwPA).....	180
Figure 7.2: A rainbow appears in the sky when sunlight hits water droplets	181
Figure 7.3 & 7.4: Shows energy conversion when threshing and the threshing in practice	182
Figure 7.5: Indigenous technology for drawing water from well to mediate learning of the concepts of kinetic and gravitational potential energy	183
Figure 7.6: Calabash- <i>Hupa</i> for churning fermented milk.....	188
Figure 7.7: Community members at Sapira farm thrashing- <i>Kupuma</i> sorghum where energy is converted	189
Figure 7.8: Sorghum grains are ready to be separated from their stalks by Onane Makena goMukwanzadi.....	190
Figure 7.9: Members sitting around the fire and telling stories.....	191
Figure 7.10: Arrow and bow are aimed at the target by the hunter	191
Figure 8.1: Lyato's classroom arrangement.....	198
Figure 8.2: Involving learners in demonstrating convection current activity.....	199
Figure 8.3: Kaurungi presented a daily life application on convection	201
Figure 8.4: Kaurungi clarifying the explanations of Figure 8.3	202
Figure 8.5: Refraction of light in bow fishing arrow	203

Figure 8.6: A sketch of Grade 10 physics learners of bow fishing arrow from Figure.8.5	203
Figure 8.7: Kaurungi’s learners viewing the dispersal of light: Rainbow	204
Figure 8.8: Swinging to mediate the concept of potential and kinetic energy.....	205
Figure 8.9: Longbow and arrow for kinetic and potential energy	206
Figure 8.10: The position of the sun and the shadow through learners’ engagement	208
Figure 8.11: The riverbank where the couple shouted as to who should go to a wedding and who should remain at home	209
Figure 8.12: The moral of the story is all about the reflection of sound: Echo (adapted from Liveve, 2017, p. 72)	209
Figure 8.13: A community girl sieving the fine flour particles to pass through the holes of the sieve	216
Figure 8.14: Types of sledges as a mode of transport in the Ukwangali community.....	216

List of Tables

Table 4.1: Profile of the Grade 10 physics teachers	102
Table 4.2: Data gathering strategies at different stages	110
Table 5.1: Themes emerging from semi-structured interviews	123
Table 5.2: Theme, sub-themes and categories grounded in data from semi-structured interviews from seven Grade 10 Physics teachers.....	125
Table 8.1: Observed lessons from the three Grade 10 physics teachers who participated in this phase for cycles one and two (Kaurungi, Lyako & Mburu)	195
Table 8.2: Themes that emerged from observed lessons	211

List of Abbreviations and/or Acronyms

AASIKS:	African Association for the Study of Indigenous Knowledge System
CLB:	Cultural Knowledge Broker
CAPS:	Curriculum and Assessment Policy Statement
CAT:	Contiguity Argumentation Theory
CK:	Content Knowledge
CoP:	Community of Practice
DAIM	Dialogical Argumentation Instructional Model
ECM	Expert Community Members
ETSIP:	Education and Training Sector Improvement Program
HOD:	Head of Department
IK:	Indigenous Knowledge
IKS:	Indigenous Knowledge System
IS	Innovation system
LCE:	Learner-Centred Education
MEC:	Ministry of Education and Culture
MEAC:	Ministry of Education, Arts, and Culture
MLE:	Mediated Learning Experience

MKOs:	More Knowledgeable Others
MoE:	Ministry of Education
NCBE:	National Curriculum for Basic Education
PAR:	Participatory Action Research
PCK:	Pedagogical Content Knowledge
PK:	Prior Knowledge
PLC:	Professional Learning Community
SAARMSTE:	Southern Africa Association for Research in Mathematics, Science and Technology Education
SCT:	Socio-Cultural Theory
SRI	Stemulated Recall Interviews
STEM:	Science, Technology, Engineering, and Mathematics
STEAM	Science Mathematics Engineering, Arts and Mathematics
SSI:	Semi-Structured Interview
TIMSED:	Transformative Model of Education for Sustainable Development
TSPCK:	Topic-Specific Pedagogical Content Knowledge
WKS:	Western Knowledge System
WS:	Western Science
WHO:	World Health Organization
ZPD:	Zone of Proximal Development

Translation of Concepts

Local meaning	English meaning
<i>Etwiso</i>	Hexagon chisel
<i>Sikumba</i>	Basket
<i>Munkudi</i>	Bascia albitrunca
<i>Ugongo</i>	Mangetti
<i>Uguva</i>	Pterolcapus angolensis
<i>Hupa</i>	Calabash
<i>Yovamba</i>	Circumsion
<i>Marenga</i>	Senior chief councilors
<i>Vanturagumbo</i>	House-heads
<i>Masimbi</i>	chief councilors
<i>Hompa</i>	Chief
<i>Ngoma</i>	Drum
<i>Kudurura</i>	Tuning by warming
<i>Kurunda</i>	Mount skin over a drumhead
<i>Kupuma</i>	Threshing
<i>Kusika hupa</i>	Churning
<i>Kahanda</i>	Silo
<i>Simaka</i>	Grewia retinervis
<i>Ekongoro</i>	Rainbow
<i>Sihiho</i>	Wig
<i>Matjakili</i>	Alto
<i>Nkinza</i>	Soprano
<i>Nkurugoma</i>	Base
<i>Rudeve</i>	Rattle
<i>Enongo</i>	Wax
<i>Kupara nohuki</i>	Shaving
<i>Mudukuto</i>	Blast furnace
<i>Shukulu</i>	Grandfather

CHAPTER ONE: SITUATING THE STUDY

Educating all learners “not only about Indigenous content but also from Indigenous perspectives and with Indigenous ways of knowing, is a key part of transforming Indigenous and non-Indigenous relations” (Lamb & Godlewska, 2021, p. 15)

1.1 Introduction

The study explored how to mobilise the indigenous technology of *drum making, drumming, music, and dance* for cultural revitalisation and indigenisation of the science curriculum. This was triggered by the fact that most science teachers seem to be grappling with how to integrate IK in their science teaching (Ogunniyi, 2007a; Seehawer, 2018a). Moreover, the teaching of science is mostly done in westernised ways resulting in it being decontextualised and thereby perceived as abstract (Aikenhead, 2020; Gwekwerere, 2016).

For instance, many science teachers in Namibian schools do not seem to be making use of IK in their classrooms, even though this is a requirement of the science curriculum. I assume that the possible reasons why science teachers do not integrate IK might be attributed in part to the fact that the science curriculum is not explicit enough on how IK should be integrated into science teaching. As a result, science is taught in decontextualised ways resulting in it being irrelevant to learners’ everyday lives as reiterated by Gwekwerere (2016) and other scholars. Yet, as stated in the epigraph above, indigenous ways of knowing are “a key part of transforming Indigenous and non-Indigenous relations” (Lamb & Godlewska, 2021, p. 15).

It is against this background that this study explored how to mobilise the indigenous technology of *drum making, drumming, music, and dance* for cultural revitalisation and indigenisation of the science curriculum.

1.2 Background of the Study

In 1990, Namibia gained independence from South Africa. Until then, Namibians had lived under German colonial rule from 1894 to 1915 and South African rule from 1915 to 1989 (Samudzi, 2021) both of which sought to deprive the indigenous population of not only their land, basic human rights and dignity but also their IK. The apartheid system which was introduced into South Africa by the Afrikaner Nationalist Party after their election into power in 1948 was subsequently applied to Namibia. In consequence, passed laws, a contract labour system and Bantu Education were introduced. Notably, the Bantu Education system which was formally introduced into Namibia in the 1960s was Eurocentric and it excluded the IK (Gwasira, 2020).

When Namibia gained independence in 1990, educational reforms were prioritised. For instance, the Founding President of Namibia, Dr Sam Nujoma once said: “The only way we can redress the apartheid legacy is by a massive education and training program for our people” (Ministry of Education and Culture [MEC], 1993a, p. ii). Succeeding the defeat of apartheid, the 1990s witnessed serious attempts by Namibians to reconstruct their social institutions along democratic lines, and education was not excluded from such efforts (Fumanti, 2021).

For instance, when I first entered formal education, a learner-centred curriculum had just been introduced in Namibia in 1990. At that time, the Namibian teachers were still grappling with and were overwhelmed by the changes related to the new curriculum. Numerous programmes were introduced and the main goals for such reforms were to increase *access, equity, quality, and democracy* in education (MEC, 1993a).

Mainly, the Namibian educational reform is guided first and foremost by the policy statements in ‘Towards Education for All’ (MEC, 1993). The new educational system, as described by ‘Towards Education for All’, is built on and anchored in Learner-Centred Education (LCE) (Nyambe, 2008) and is aimed at harnessing curiosity and excitement and promoting democracy and responsibility in lifelong learning. The stated intentions of the system are to employ a holistic view of learning, value life experiences and assist learners in integrating school and life outside school (MEAC, 2016). Notwithstanding these ideals, the fact that the curriculum has changed and the content is more complex than in the old curriculum, might make it more of a challenge for teachers to make science relevant to learners (Davidowitz & Rollnick, 2011). This suggests that teachers should

adopt instructional strategies that learners can relate to, to understand science concepts as proposed by Mavuru and Ramnarain (2020).

Moreover, the MoE in Namibia mandated that IK, pedagogy and worldviews be embedded in all curricula. But many science teachers seem to be unable to fulfil that directive because they are unfamiliar with indigenous cultural technologies. It is against this backdrop that I designed this study, informed by indigenous protocols and worldviews, to address this gap in knowledge and understanding. In so doing, I hoped that the Physics teachers involved in this study might learn how to enact the new curriculum effectively. That is, in a way that aligns with indigenous peoples' ways of knowing (Mukwambo et al., 2014; Smith, 1999).

1.3 My Personal Life Story – Situating Myself in the Study

When we locate, we are saying 'This is just my view.' It's not the view of the Anishnabe nation because I'm not Anishnabe. It's not the view of the Coastal nations. It's not the view of a 100 per cent, full-blooded Cree. It's not the view of women. It's just my view and this is who I am. This is my mother. This is my father. These are my ancestors. This is where I grew up geographically. This was my experience as I grew up. And based on all of those things, this is what I think. (Absolon & Willett, 2005, p. 105)

As the author of this thesis, I took my cue from Absolon and Willett's (2005) views in this quote to locate what I have written from an understanding of who I am and how I have come to my worldview. Complex and encrusted, my social, political and cultural identities have given shape to my assumptions and perceptions of the world as well as my experiences within it. I am just like any other African child who was given a name with a meaning.

For instance, Kanyanga¹ is my birth name and I got Angelius after my 10th birthday which was witnessed by my godparent in the Roman Catholic Nkurenkuru Parish (St. Fransiskus). That is to say, my name is Kanyanga Angelius Liveve. I am the son of Hamutenya Cilunda Liveve and Mariane Intumba. I was born a twin two years after the beginning of the Angolan civil war in 1975 and at the time when my parents fled from Angola to Namibia. I, therefore, grew up in Mayara Village (Royal area) in the Kavango West Region, where we spoke the Rukavango language of

¹ In the principle of Ngangela – for Vanyemba the name 'Kanyanga' is given to a person left behind when the twin brother has passed on at a tender age, not older than three.

the Rukwangali. Moreover, I spent my childhood years in the homestead of 12 sections led by Granny-*Kuku* Rossa Kakuhu kaThikila. I was raised and cared for by my elder brother – *Lyambombola*² and his wife Kahanzi. I was viewed as the firstborn in the family and never considered an outsider even in the homestead of my sister-in-law as a result of Ubuntu (Ogunniyi, 2007a; Seehawer, 2018a), in which a person is a person through other people. The Ubuntu perspective has encouraged me to behave well towards others or act in ways that benefit my family and community at large.

Culturally, I had no cousins, aunts and uncles as other African cultures do. We only used the terms brothers, sisters, elder, and young mothers and fathers. Moreover, everyone was regarded as part of a large family. Indeed, that resonates with the African adage that it takes a village to raise a child. Neighbours who were not direct relatives always had their families and found their clan lineage through animal totems such as hyena-*Mukwasipika*, frog-*Mukwankora*, cattle-*Mukwangombe*, lion-*Mukwanyime*, eagle-*Mukwanzadi* and locust-*Mukwambahu*. In addition, these clans have different names, for instance hyena-*Mukwasipika* in Rukwangali, *Mukachinkumba* in Runyemba, *Hakasheya* in Thimbukushu, *Omukwanekamba* in Oshikwanyama and *Ngcuka* in isiXhosa which is my clan. The community members are interrelated by marriages, religion, politics and works.

On reflection, as I was growing up elders could tell the probability of rainfall from a distance by observing lightning flashes and the sound of a thunderstorm that was heard a bit later after seeing the lightning flashes. Moreover, the elders would also use the appearance of flight flocks and the flight of insects to predict whether the rain would be heavy or not. So, they would tell the boys not to take cattle far into the jungle and cautioned them not to stand under tall trees or in an open space to avoid being struck by lightning. Such knowledge was and still is valuable to our local societies. Similarly, Risiro et al. (2012) aver that indigenous knowledge systems (IKS) have been used by rural communities to predict weather and seasonal changes in their environment. This suggests that elders considered the environment to make sense of the world (von Humboldt et al., 2020).

² *Lyambombola* is a name given to a person who is talkative in the community.

Regarding food preservation, *Shukulu*- Omama wovagara (grandfather) by the name Andimankuru stored milk in *hupa* (calabash) with roots from *munkudi* which made milk ferment faster so that it could turn into sour milk-*mbofu*. These roots from the *Bascia albitrunca* (Shepherd's tree- *munkudi*) were used as a catalyst that speed up the chemical reactions. The process of milking cows is done by young men, which occurs before or after fetching cattle from the forest (see Figure 1.1 below).



Figure 1.1: Kanyanga Angelius Liveve milking a cow in a cultural way

But the time came for me to attend school. I remember that started a bit late in my Grade 1 class and hence I was the tallest boy in class when queuing. Wearing a school uniform and carrying a schoolbag were theoretical activities to me because my parents were very poor. For instance, I improvised and used a plastic bag as a school bag. In hindsight it could be argued that I was introduced to the use of easily accessible resources at a young age as reiterated by Asheela et al. (2021) and other scholars.

Nonetheless, I believe that life taught me that there is a reason for everything and that I had to use time efficiently. There was a time for school activities, home and business. Regarding business, for instance, every weekend and after school, my brother, sister-in-law and I collected berries (Mangetti fruit) *Nongongo* for making *Kasipembe/Kacipembe* for income so that we could put food on our table. But unfortunately, I did not observe how such a traditional beverage was made

since the school did not permit schoolgoing children to associate themselves with this kind of indigenous technology called distillation- *kukendja*.

At school, we were committed to memorising prayers, English rhymes and folk stories enthusiastically although we did not understand them. At home, I used to observe my *suwara* (sister-in-law) dipping her finger in water to determine its hotness or coldness. That experiential learning could be used when explaining the term temperature. Yet, my experience at school was different from the experience at home. That is, the everyday tasks and life stories were not taken into consideration at all. Sadly, such knowledge was not acknowledged by the school system as a foundation on which learners could build new knowledge.

Yet, Kuhlana (2011) refers to such knowledge as prior everyday knowledge which is part of the socio-cultural background of learning according to Mavuru and Ramnarain (2020). Admittedly, the two knowledges, IK and westernised knowledge, are underpinned by different worldviews and are often presented as binary opposites (Herbert, 2021; Ogunniyi, 2007a) and so we need to find ways of integrating them into the science classrooms. In this regard, scholars such as Seehawer and Breidlid (2021) aver that there should be a dialogue between these knowledges rather than viewing them as mutually exclusive as seems to be happening in most schools.

At my primary school, Siudiva Junior Primary school, now known as Kanuni Haruwodi Combined School, male learners were taught how to play the drums while the female learners sang cultural songs, clapped hands and played rattles-*marudeve*. People from the nearby communities were allowed to come and watch the drumming, singing and dancing. The school principal used traditional music and dance to pass on knowledge about politics (voters' education and the party to be voted for) in the vernacular language of *Rukwangali*. Regrettably, teachers from that school could not use such an opportunity when implementing the science curriculum. What a lost opportunity!

During the rainy seasons, I had to plow (cultivate) the fields before attending school. As a result, I usually arrived about 10–15 minutes late after the commencement of the first lesson. Similarly, I was only able to attend the first four lessons and did not attend the last four lessons because the boys had to go and look after cattle. Such a practice was against the school's policy as reiterated

by Jirata (2021). At home, my brother and mother would wake me up in response to the alarm of the rooster's crow or other early morning birds such as fork-tailed drongo-*ntene*. The only place where I was able to respond to nature and determine the time by using the sun, moon, stars, birds and roosters was Mayara, my home. That is where I had an opportunity to sit around the fire and enjoy folk tales or stories as postulated by Duarte et al. (2021).

During my two years of senior secondary school at Leevi Hakusembe secondary school, I worked closely with my mathematics, Biology and Physical Science teachers (Ms. Alice Lee and Ms. Graham) and classmates like NyaForsta, Sipwa³-Alloysia Katamba, Alpheus Hausiku, Ndungo Herman, Katjaka Paulus and the late Rosa Zokka (May her soul rest in peace!) to name a few. I remember that my Physics, Chemistry, and Biology teacher provided me with an opportunity to deliver her subject lessons to my classmates and other groups in Grades 12B-C of the year 1999. However, I did not experience any single way of integrating IK in both Mathematics and Science teaching.

In Physical Science lessons, I was introduced to the concepts such as catalyst, rate of reactions, energy conversion and light and sound waves to mention a few. On reflection, my Physical Science teachers could have connected me to these concepts by tapping into the indigenous technologies practiced at home. Yet, none of this was mentioned during my primary and secondary schooling. However, I do not blame my teachers for such since they inherited the colonised curriculum that was delivered in a Eurocentric discipline. Indeed, I have no reason to. Throughout, I just turned to rote learning without understanding. Such rote learning meant that I did not master many of the science concepts because my prior everyday knowledge learnt at home was not taken into consideration (Kuhlana, 2011); hence, I could not relate to the knowledge taught as pointed out by Gwekwerere (2016).

Upon completion of the Basic Education Teacher Diploma (BETD) training in 2002, I had no idea how to identify such knowledge called indigenous or everyday knowledge, although most of the Grade 5 Natural Science and Health Education learners at the school where I started teaching in

³ cousin

2003 were able to use their everyday knowledge when given tasks to discuss in a group. For instance, there was a lesson about poisoned substances in Natural Science and Health Education. The Grade 5 learners were asked to list examples of substances that they regarded as poisonous and the majority of them listed *Emangweni*. *Emangweni* was a name given to a 64-seater bus that transported people from Nkurenkuru to Rundu daily except Sundays. That bus had the word ‘Poison’ written on the back which made learners think that the bus called *Emangweni* is a poisonous substance. I regret not knowing that these Grade 5 Natural Science learners were using the knowledge they had from their experiences – and that it was necessary to correct their errors and at the same time, acknowledge their everyday knowledge. Could it be the reason why Taylor (1999) cautions that prior knowledge is not educational?

Moreover, I did not carefully consider the role of prior everyday knowledge and the use of hands-on practical activities in science as a method of promoting the hands-on, minds-on, and words-on approach (Asheela et al., 2021). Admittedly, there is time for everything.

In 2015-2016, during the research design course in 2015, I was exposed to a practical demonstration and explanations of making ⁴*umqombothi* by Mama Noling, an expert community member at Rhodes University. Indeed, her presentation was in a multicultural teaching session. Interestingly, she did her presentation in her home language, isiXhosa, and another master’s student translated it into English so that my colleagues and I could understand. It could be argued that during her demonstration, isiXhosa as a language was used as a resource as accentuated by scholars such as Mavuru and Ramnarain (2017), Msimanga and Lelliot (2014), Ngcoza (2019) and Nhase (2019).

Upon completion of my master’s, I proceeded to do a PhD in Science Education at Rhodes University. This has equipped me with the knowledge to realise the role and value of IK in the science curriculum. Both Namibian Colloquiums, the Southern African Association of Research in Mathematics, Science and Technology Education (SAARMSTE) and the African Association for the Study of Indigenous Knowledge System (AASIKS) have also played a role in me acquiring

⁴ *Umqombothi* is a traditional alcoholic beverage made by some families, in particular Xhosas in the Eastern Cape, South Africa (Mutanho, 2021).

relevant knowledge about integrating IK into the science curriculum. I am now able to integrate IK into most of my science teaching.

In my earlier years of teaching, however, I regret not knowing that IK could be used as a foundation on which new knowledge can be built as suggested by Roschelle (1995) and other scholars such as Nhase (2019), Ntoko and Schmidt (2021) and Selaledi et al. (2021) for comprehending the realities. That is, there is a need to take into consideration learners' diverse socio-cultural backgrounds (Mavuru & Ramnarain, 2020; Vygotsky, 1978).

1.4 My Positionality and Reflexivity

One of the major predicaments in educational research is that of positionality. Skelton (2001, p. 89) refers to positionality as factors that “impact on the way we do our research and how the people we work with perceive us”. Since most of my research participants, both Grade 10 Physics teachers and the Unongo Cultural Youth Group, were my former learners, the issue of positionality and power dynamics would inevitably arise. Being an indigenous researcher, I have an indisputable position in the research process and such positionality might affect the nature of observations and interpretations that I made. This proposes that the subject of positionality, power and representation play a role in conducting research.

For instance, at the time when I conducted this study, I was an acting principal at one of the schools in the Kandjimi Circuit, the Chairperson of the Council Management Committee of Nkurenkuru Town Council and a part-time lecturer at the International University of Management for Nkurenkuru campus as well as a PhD scholar at Rhodes University which I believe might have impacted the study in terms of positionality. In addition, my clan's name is hyena-*Mukwasipika* and my wife's clan name is eagle-*Mukwanzadi*. Such a clan name bestowed additional power upon me.

Hence, I addressed the matter of positionality by guaranteeing that all participants in this study knew and understood that their participation was voluntary and that they were free to withdraw from participating in the research at any time they felt like doing so, as per Rhodes University's ethics requirements (Mutanho, 2021). However, Mutanho (2021) cautions that this becomes problematic when this statement is translated into the vernacular. For instance, it emerged from

him that the participants felt that it was disrespectful to tell them that they could withdraw at any stage of they felt like it. Such findings point to the need for higher education institutions to be sensitive to ethics from an African perspective as well.

Further, positionality is usually identified by locating the researcher in three areas: “(1) the subject under investigation, (2) the research participants, and (3) the research context and process” (Holmes, 2020, p. 2). It is for this reason that I built a strong relationship by regularly visiting both Grade 10 Physics teachers and the expert community members (Mutanho, 2021; Seehawer et al., 2022). Such visits allowed us to know one another better. Regarding community members, through such an engagement I was able to know the duties and responsibilities they executed in their groups.

Culturally, in the Ukwangali community where the study took place, people are related to each other in many ways such as by clans. The fact is that the principle of clan names was considered a priority for me, so that I could find out who my sister, brother, grandparents, mother and father were. As I alluded to earlier, the words cousin, uncle and aunt do not exist in the Ukwangali community. In doing so, I created respectful ways of addressing each other. This approach allowed me to reduce bias in both how the research was conducted and ways of gathering data. Moreover, the participants and I agreed to use the vernacular languages *Rukwangali* and *Runyemba*. Resultantly, everyone felt comfortable. In support, Seehawer (2018a) posits that when the culture of participants is guided by the spirit of Ubuntu, all participants look forward to the mutual dialogue where every person’s opinion is equally valued with no dominance.

To deal with the power imbalance, I positioned myself as a co-learner in this study. That enabled me to be reflexive throughout my research journey. For instance, since the integration of IK is a considerable challenge as revealed in the National Curriculum for Basic Education (MEAC, 2016) for many teachers, many of us could not claim to be experts on the indigenous technologies of *drum making, drumming, music* and *dance* in particular. My research journey, therefore, involved reflecting on and taking action throughout the research process (reflexivity) to avoid any biases and assumptions. The trustworthiness of qualitative case study could be affected by the closeness of the relationship between the research participants and me, which would develop during the

prolonged interactions deemed necessary to establish trustworthiness. Moreover, this closeness could create difficulties in separating my experiences from those of the participants.

To attain the truth-value of the qualitative study, reflexivity could be a strategy to help ensure that the “overinvolvement” of the researcher is not a threat to the credibility of the study (Chilisa, 2012, p. 147). Reflexivity in this context refers to the assessment of my influence, the ways of perceiving reality, my experiences, ideological biases and interests during the course of the research. Towards the end of every workshop, I showed respect by asking the participants about their calendar of activities and for them to suggest the possible date for the next workshop. That is, reflexivity enabled me to humble myself throughout the research process and beyond.

1.5 The Statement of the Problem

The recognition of IK in education represents an acknowledgement of diversity, something consistent with the Namibian Constitution in which culture is emphasised in Article 19. Also, the goal of a curriculum gives the overall direction for education whereby the National Curriculum for Basic Education (NCBE) (MEAC, 2016, p. 5) in the context of globalisation states that it is “important that an individual, a culture and a nation should not only have knowledge and skills in a knowledge-based society, but also a strong identity and positive values”. That is, knowledge encompasses IK, and local and national culture.

It is argued, therefore, that IK integration has a strong cultural and individual identity and positive values for the possible influence of globalisation. It is against this backdrop that in Namibia, the integration of IK is a requirement that is supported by the national curriculum. This includes the strong collaborative culture which is characteristic of African society. However, many challenges affect the implementation of the integration of IK into the classrooms (Theodory, 2021). Such challenges seem to be exacerbated in part by the fact that school science places side by side two radically different knowledge systems originating from different underlying assumptions (Khupe, 2014; Mutanho, 2021; Ogunniyi, 2007a).

On the one hand is school science, which originates in a culture of written knowledge and is, therefore, more clearly structured for teaching and learning. Notably, experts in science education who were trained in westernised ways are involved in the development of national curriculum

documents, textbooks and even online resources. Resultantly, westernised science seems to be dominant in schools (Ogunniyi, 2007a).

On the other hand, IK originates in oral cultures and resides in the hearts and minds of elders and the expert community members (Lavallée, 2009), and those who possess the knowledge do not necessarily look at publishing it (Ochwo-Oburu, 2020). Hence, many science teachers in Namibian schools seem not to be making use of IK in their classrooms even though this is a requirement of the science curriculum. Namibia, like many southern African countries, aims to become a knowledge-based society with a well-established innovation system with a particular focus on the integration of IK.

Essentially, embedding IK in innovation policies at HEIs is often seen as an opportunity to adjust the general concept of ISs to local contexts and practices and include bottom-up approaches in policies (Mutanho, 2021; Seehawer, 2021). In Namibia, the establishment of key institutions and strategies for an IS is supported by international development aid. In operational IS practices, the focus on a science technology innovation mode of learning that requires high analytical knowledge and a well-functioning IS seems to be rare in Namibia (Hooli & Jauhiainen, 2018). As a result, trained teachers are not fully equipped with the knowledge on how to integrate IK into science classrooms.

In addition, many science teachers from under-resourced schools, in particular, seem to find science difficult to teach citing a lack of resources as a hindrance (Asheela et al., 2021). As a result, learners seem to find science difficult to comprehend. For instance, the examiners' reports (MEAC, 2016-2021) revealed that learners struggle to answer questions on sound as an example. It could be argued that this is because science is decontextualised and not relevant to learners' everyday lives (Gwekwerere, 2016). This makes the integration of IK into science teaching very necessary.

It is against this background that this study explored how to mobilise the indigenous technology of *drum making, drumming, music, and dance* for cultural revitalisation and indigenisation of the science curriculum. This interventionist study was further motivated by the fact that most science teachers seem to still be grappling with how to integrate IK into their science teaching.

1.6 Purpose and the Significance of the Study

This study sought to contribute to social justice by exploring how to mobilise the indigenous technology of *drum making, drumming, music, and dance* for cultural revitalisation and indigenisation of the science curriculum. The study centred on Grade 10 Physics teachers to expose them to pedagogies that harness cultural heritage (IK) when teaching Physics on the topic of sound as an example. Moreover, the study sought to build a partnership with expert community members and the implementors of the science curriculum. It was hoped that the community members' involvement would increase and their efforts to be involved in supporting schools encouraged (Klein, 2011).

On a personal level, this study enhanced my career growth by taking a step toward advancing learning and understanding more about the integration of IK. Also, I disseminated my research widely by participating in the SAARMSTE and African Association for Research in the Studies of Indigenous Knowledge System (AASIKS) conferences as well as the SAARMSTE Research School.

The study also has implications for both Physics teachers and me as it helped us to improve how to integrate IK into our teaching. The study is also of significance to the participants as it created opportunities for them to enhance their pedagogical content knowledge (PCK) on how to integrate IK into science teaching (Mavhunga & Rollnick, 2013; Ogunniyi, 2018; Shulman, 1986).

1.7 Research Goal and Research Questions

1.7.1 Research goal

The main goal of this study was to mobilise the indigenous technology of *drum making, drumming, music, and dance* for cultural revitalisation and indigenisation of the science curriculum. To achieve this goal, the following research questions were addressed:

1.7.2 Research questions

1. What are Grade 10 Physics teachers' experiences, pedagogical insights and attitudes toward the use of IK in science teaching?

2. How do the Grade 10 Physics teachers interact, participate and learn (or not) during the expert community members' practical demonstrations and explanations on *drum making, drumming, music and dance*?
3. How do the Grade 10 Physics teachers integrate the cultural knowledge from the community members on *drum making, drumming, music and dance* when co-developing exemplar lesson plans?
4. How do Grade 10 Physics teachers mediate learning during enactment of the planned exemplar lesson in their classrooms?

1.8 Theoretical Frameworks

In this study, I used Vygotsky's (1978) socio-cultural theory (SCT) and Ogunniyi's (2007a) Contiguity Argumentation Theory (CAT) to analyse the data. I briefly discuss each framework below.

1.8.1 Socio-cultural theory

Vygotsky's (1978) SCT claims that all of us learn first through person-to-person interactions and then as individuals through an internalisation process that leads to deep understanding (Dugas & Morgan, 2021). Vygotsky (1978) proposed that learning rouses a variety of internal development processes that can work only when the child is interacting with the grandmaster in their environment and with their peers. Within Vygotsky's (1978) SCT, I used the following key concepts: mediation of learning, culture and language, social interactions and the zone of proximal development (ZPD) when conducting the intervention of *drum making, drumming, music and dance* in which the skills of integrating IK into teaching science are promoted.

1.8.2 Contiguity Argumentative Theory

Ogunniyi (2007a) emphasises that the CAT happens when two different cultures co-exist or are in conflict and is only possible through cognitive shifts to accommodate each other. In addition, he posits that argumentation has been used as a rhetorical and instructional tool in many different societies. With Ogunniyi's CAT, I used the following key concepts – dominant, suppressed, assimilated, emergent and equipollent domains for the effective participatory action study of mobilising the indigenous technology of *drum making, drumming, music and dance* for cultural revitalisation and indigenisation of the science curriculum.

1.9 Data Gathering Methods

In this study, I used numerous data gathering methods to answer my research questions, namely interviews (semi-structured and stimulated interviews), observations (participatory observations and videotaped lessons) and journal reflections. In light of this, Solano (2020) proposes that using different data gathering methods helps with the triangulation of data. Concurring, Koo et al. (2020) maintain that these multiple methods might provide more holistic and comprehensive data.

1.10 Definition of Terms

In the context of this thesis, I have used many terms that could have different meanings in other contexts or could be written differently. Therefore, I explain below the meanings these terms are meant to convey in this study, or the way I decided to write them in this thesis.

Community member: I use this term when referring to the Unongo Youth Cultural Group which is the custodian for the cultural technology of drum making, drumming, music, and dance.

Communities of practice: These are groups of people who share a concern or a desire for something they do and learn how to do it better as they frequently interact (Wenger, 2006).

Context-based learning: In the context of the study, it is an approach that depends on the value of the scientific concepts presented through certain means by establishing contexts and relationships carefully chosen from learners' daily life practices (Barker & Millar, 1999; Gilbert, 2006; Ulusoy & Onen, 2014).

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

Cultural knowledge broker: In the context of the study it is concepts used to describe Grade 10 Physics teachers who acted as intermediaries and negotiated between outwardly different cultures, languages, and social and political systems (Wyatt et al., 2017).

Cultural revitalisation: In the context of the study, it is the practice of promoting and recognising cultural identity which through time, seems to be lost and on the verge of dying out, by providing the space for and acknowledgement of local cultural values. If these values are not acknowledged, these cultural identities will end up not existing (Cocks et al., 2012; Smith, 1999).

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 standards of Physics.

Indigenous: In the view of the colonial masters, the term indigenous was associated with the primitive, the wild, the ignorant and the natural but it is defined as “to be born in a specific place” (Hogarth & Rapata-Hanning, 2015, p. 1244). Moreover, Tuulentie et al. (2020) emphasise that indigenous entails belonging to or originating in an area or natural living, growing or producing in an area.

Indigenous knowledge (IK): Specific forms of knowledge that are local and specific to a place. In languages where verbs are more central than nouns, IK could be synonymous with “ways of knowing” (Chilisa, 2012, p. 177).

Indigenous Knowledge Systems (IKS): The totality of the knowledge that a community holds which includes worldviews and is, therefore, broader than IK (Khupe, 2014).

Indigenous Technology: This is part of IK and is part of the life of the rural poor because their livelihood depends almost entirely on specific skills and knowledge for their survival (Emeagwali & Shizha, 2016; Parajuli & Maharjan, 2017).

Local: Applied to different geographic contexts, but it lacks specificity. The context of the study is interpreted as a cumulative body of knowledge, practices and representations that describe the relationships of living beings with one another and with their physical environment, which evolved through adaptive processes that have been handed down through generations by cultural transmission.

Mediation of learning: This is the connection between the existing states of mental development through the ZPD (Hughes, 2021).

Knowledge: This is a product of human thought, action and experience. Each culture contains a knowledge base from which its members receive an understanding of the world. Also, knowledge is the “whole body of cognition and skills which individual use to solve problems. It includes theories and practices, everyday rules, and instructions for action. It is constructed by individuals and represents their benefit about causal relationships” (Plockey, 2015, p.13).

Prior everyday knowledge: This is the kind of knowledge that the learners possess and explore through their social and material environment and learn through communication with others (Kuhlane, 2011; Vygotsky, 1978).

Positionality: This is a factor that impacts the way we do our research and how the people we work with perceive us (Powell, 2021) and “reflects the position that the researcher has chosen to adopt within a given research study” (Holmes, 2020, p. 2).

The professional learning community: This is a group of organised people that meets 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 has the focused role of helping 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 (Wyatt et al., 2017).

Reflexivity: This entails reflecting and taking action throughout the research process (Holmes, 2020).

Research: This is a critical process of steps that typically begins with identifying a research problem or issue of a study. It then involves reviewing the literature, specifying a purpose for the study, collecting and analysing data and forming an interpretation of the information (Johnson et al., 2020).

Social interactions: This is the mechanism of sharing functions and a method of understanding those functions (Rubtsov, 2016).

Sound: This is the phenomenon we experience when our ears are disturbed by vibrations in the air or solid objects that surround us (Kadis, 2015; Liveve, 2017).

Traditional dance: This is a dance in an ethnic group that is considered by most members of the group to be their cultural heritage (Liveve, 2017; Nwauzor, 2021).

Ubuntu: This is the belief in a universal bond of sharing that connects all humanity. Ubuntu is an African-centred worldview that emphasises good-of-all, harmony, mutual respect, relational understanding, interdependence, interrelationships or interconnectedness of all phenomena (Ogunniyi, 2007a; Seehawer, 2018b).

Unongo Youth Cultural Group: This is a non-profitable social-cultural group administered by outgoing school youths of Yinsu to promote their immediate cultural heritage and identity.

Waves: These are a type of energy transmission that results from a periodic disturbance (vibration) and are composed of a series of repeating patterns (Zhang et al., 2021).

Wooden Drum-*Ngoma*: The drum is handcrafted using traditional methods and a solid wood frame wrapped with durable African cow or goat skin (Liveve, 2017). It is a rhythm instrument made from wood in the community of Ukwangali and different sounds are made when percussionists tap on different locations on the drumhead – they are played during many African celebrations, including weddings and a full moon.

A worldview: This is a person's thinking and understanding of the world and their being in the world. The values that a person holds often result from their worldview.

ZPD: This is the distance between the actual developmental levels as determined by the independent problem-solving of an individual and the level of potential development as determined through problem-solving in collaboration with more capable peers (Vygotsky, 1978).

1.11 Thesis Outline

This thesis consists of nine chapters and I outline these below.

Chapter One is an introductory chapter aimed at situating this study. It started with a brief introduction after which I presented my own life experiences of viewing IK and Western Science (WS) as a schoolgoing child. Thereafter, positionality and reflexivity were explained. The chapter then focused on the statement of the problem, the purpose and significance of the study as well as

the research questions before turning to the theoretical lenses that guided this study. The chapter ends with a definition of the key terms to this study, a thesis outline and a chapter summary.

In **Chapter Two**, the literature reviewed related to the study is discussed. I introduce the concepts that fall within the conceptual framework. The conceptual framework discusses concepts like Namibian curriculum, professional learning community, hands-on Physics practical activities and visualisation, communities of practice, wooden drum-ngoma, the value of IK and WS, IK embedded with concepts of sound and echoes, worldview, the Physics of sound and the chapter summary.

In **Chapter Three**, the theories discussed are SCT in general and Ubuntu, as it aligned with the social philosophy from the SCT (Vygotsky, 1978). The views of the SCT discussed are those from Vygotsky (1978); most especially the intrapsychological and interpsychological levels and the ZPD. Also, I examine some views in social theory and how they can bring about some changes in the practices of Grade 10 Physics teachers and the main key aspects of SCT like culture and learning, mediation of learning, social interactions and engagement and ZPD. These views of IK are discussed and how they can contribute to facilitating the integration of IK into under-resourced schools. Finally, the ontogenesis of SCT is outlined, and how concepts in it contribute to this research study are discussed.

In **Chapter Four**, the methodology used in the study is discussed. The chapter opens with an introduction, followed by the indigenous research paradigm and Ubuntu perspective. Developmental work research as the methodology is discussed and its tenet, the Ubuntu perspective, and its stages are explained.

In **Chapter Five**, data generated using semi-structured interviews are presented. These instruments were responsible for generating data to address research question 1, which wanted to understand Grade 10 Physics teachers' experiences, pedagogical insights and attitudes towards the use of IK in science lessons. Themes were developed for this chapter.,

Chapter Six explores the Grade 10 Physics teachers' interactions, participation and learning (or not) during the expert community members' practical demonstrations and explanations on *drum making, drumming, music* and *dance*. The teachers' interactions and participation during the

practical demonstrations and explanations were essential to gathering their comprehension of the value of integrating IK when teaching concepts of sound for Grade 10. Instruments used for generating the data were participatory observations, reflective journals and stimulated recall interviews.

Chapter Seven present data for research question 4a of this study after Grade 10 Physics teachers were engaged in the expert community members' demonstrations and explanations. It allowed Grade 10 Physics teachers to co-develop exemplar lessons on the topic of sound in their classroom situations.

Chapter Eight presents and discusses the data gathered from lesson observations of three Grade 10 Physics teachers. The data are analysed by relating them to the concepts in the literature review (Chapter Two). The summary of findings is discussed in the last chapter, **Chapter Nine**. Recommendations and limitations as well as the participants' experiences and benefits of being involved in the study are stated before concluding the research programme.

1.12 Chapter Summary

In this chapter, I discussed my life history and my experience in teaching and management as a rural Namibian male teacher to highlight my personal experiences of the tension between IK and WS. My study was thus built on my master's study which was an exploration of the possibility of integrating traditional music and dance into the designing and delivery of lessons in Grade 10 Physical Science (Liveve, 2017). It draws on my understanding of the context of *Ukwangali*. The historical, physical, social and economic contexts are intertwined in a complex way; however, they all served for a more holistic understanding of the research site. In all senses, these experiences advanced the development of the study, specifically, my appreciation of the research site. In the next chapter, I discuss the literature relevant to this study.

CHAPTER TWO: LITERATURE SYNTHESIS

No research problem in one field exists in isolation from other areas of human behaviour. Consequently, there is always some research study, some theories, and some thinking related to the problem that can be reviewed to inform the study at hand. (Merriam & Tisdell, 2015, p. 264)

2.1 Introduction

The literature review in this study allowed me to gain familiarity with the current knowledge on the qualitative case study, and the boundaries and limitations. Essentially, the literature review puts the research study into the context of previous research by indicating how it fits into a specific field and discussing them intensively (Bertram & Christiansen, 2020). In so doing, a literature review also helped me to gain an understanding of the theories driving the field, allowing me to place my research questions into context.

Hence, the study was aimed at mobilising the indigenous technology of *drum making, drumming, music* and *dance* for cultural revitalisation and indigenisation of the science curriculum. In this chapter, I, therefore, discuss literature relevant to the Namibian curriculum, hands-on practical activities and visualisation. Moreover, I discuss literature relevant to understanding IK and IK in sound production in particular. Again, I discuss the relevant literature concerning the nature of IK, WS, worldviews and the IK perspective in Physics teaching. The literatures on IK in the NCBE as well as the challenges of integrating IK are discussed. The chapter ends with a discussion on Physics teachers' professional learning communities central to this interventionist study.

2.2 Namibian Curriculum

Since 1990, the education system in Namibia has been characterised by many innovations at both policy and school levels. That was aimed at transforming schools into places where learners can prosper, attain good results and become productive democratic citizens. In 2010, for instance, the Ministry of Education (MoE) in Namibia introduced the National Curriculum for Basic Education

known as Curriculum 2010 (C2010), followed by the NCBE 2016 (MEAC, 2016). The main purpose of the NCBE (MEAC, 2016) was intended to improve teaching, learning and assessment. It thus gave direction to planning, organising and implementation of teaching and learning. Moreover, the NCBE provided a coherent and concise framework to ensure consistency in the delivery of the curriculum in schools and classrooms throughout Namibia in which the knowledge-based society was a priority. Although the NCBE (MEAC, 2016) encourages the integration of IK in science teaching, it seems to be silent on how teachers should go about doing it. As a result, most science teachers are still grappling with how to integrate IK. My study, thus, sought solutions to addressing the inexperience of integrating IK into science teaching. That is, I identified this as a gap in the transformation of the Namibian curriculum.

Such changes included successive new curricula, systemic assessment, programmes for the continuing professional development of teachers, heads of department and principals' catch-up programmes and advances in educational technology. Another innovation is that the Physical Science Grade 10–12 has now been split into Physics and Chemistry (MEAC, 2016), something which is intended to provide specialisation and depth in these subjects. This is also intended to prepare learners who will take three to five subjects at the Advanced Subsidiary level. Similarly, by the end of Grades 11 and 12, learners are expected to be well prepared for further studies in Physics and Chemistry at HEIs.

For instance, the Physics curriculum, which is the focus of this study, is intended to enable Namibians to continue benefiting from their experience in international education, and also to benchmark the new qualification against Cambridge standards and that of Science, Technology, Engineering, and Mathematics (STEM). The term STEM is classically used when addressing education policy and curriculum choices in schools to improve competitiveness in science and technology development. If STEM learning is truly a lifelong, life-wide and life-deep process, research designs must cut across diverse settings and investigate multiple contexts and media, rather than the historical approaches that have viewed learning within limited temporal, spatial and socio-cultural contexts (Tobin, 2016). In the context of the study, drum making, drumming, music and dance form part of Science, Mathematics, Engineering, Arts and Mathematics (STEAM).

In Physics, sound is a vibration that typically propagates (spreads) as an audible wave of pressure through a transmission medium such as a gas, liquid or solid (Kadis, 2015). For instance, beating the drum with the palms causes the skin on a drum to vibrate with a particular frequency (Liveve, 2017). Sound from a Physics perspective implies a close examination of the basic elements of sound phenomena, namely amplitude, propagation medium and length (Kadis, 2015). The extrinsic display of sound waves is known as rarefaction and compression. The effects that a sound wave has depend on the materials to demonstrate the sound production and how these materials qualify the sound wave vibration, resonance and echo.

2.3 Hands-on Physics Practical Activities and Visualisation

As alluded to earlier, this study was intended to foster cultural revitalisation (Cocks et al., 2012; Smith, 2012) and to make science relevant to learners' everyday lives and experiences (Gwekwerere, 2016). Thus, I deemed it necessary to review the literature on hands-on practical activities (Asheela et al., 2021; Shinana et al., 2021). Shulman (1987) asserts that teaching ordinarily begins with a teacher's understanding of what is to be learnt and how that is taught. In this regard, the MoE (1993a) identified learning as an active process with participation from the learners in developing, organising, implementing and managing to learn. According to Shinana et al. (2021), inquiry-based learning involves learners investigating scientific phenomena through engaging in hands-on practical activities. Hands-on practical activities are thus regarded as a significant component of the science curriculum (Asheela et al., 2021; Babalola et al., 2020).

Other scholars such as Babalola et al. (2020) and Asheela et al. (2021) highlighted that those hands-on practical activities create motivation and interest for learning science particularly Physics in the context of this study. Hands-on practical activities allow learners to learn based on the experiences and the environment they are exposed to. Similarly, there are some studies conducted in different parts of the world which have demonstrated that involving learners in hands-on and minds-on practical activities motivates and makes them more active and more engaged in science lessons (Asheela et al., 2021; Correia & Harrison, 2020; Sedlacek & Sedova, 2017).

In this regard, Mahamud (2021) postulated that learners are not empty vessels but rather come into our classes with a range of prior ideas or perceptions of the physical world. Moreover, cultures are closely related to prior ideas, providing a common set of conceptions from untaught life

experiences. As the learners become familiar with the subject they are learning, they begin to make decisions, requiring less teacher support and allowing more interactive learning experiences to occur (Babalola, et al., 2020). Herein lies the importance of visualisation in science teaching and learning.

Several terms are related to visualisation such as visual representations, visual media, media literacy, visual communication skills, visual literacy, illustrations and media illustrations (Vanichvasin, 2021). The term visualisation can be used to name a representation, to refer to the process of creating a graphical representation, or as a synonym for visual imagery (Vanichvasin, 2021). Correspondingly, Godfred et al. (2021) clarifies that visualisation can denote the *what* of visualisation (the product, object, or visual image) or the *how* of visualisation (the process, activity, or skill).

This study focused on visualisation as a means of understanding how linguistic information and visual information are encoded by two independent mental systems, a verbal and a non-verbal system (Chen et al., 2020). Using the indigenous technology of *drum making, drumming, music* and *dance*, therefore, was intended to advance the conceptual understanding of Physics teachers.

2.4 Understanding Indigenous Knowledge

In this study, I worked *with* Grade 10 Physics teachers intending to explore their experiences, pedagogical insights and attitudes toward the use of IK in science teaching. Some scholars argue that the term IK is not easy to define as there is no universally accepted definition for it (Khupe, 2014; Ogunniyi, 2007a). For instance, Khupe (2014, p.43) asserts that “both these concepts are the subject of debate in philosophy and science”. Khupe (2014) thus traced the complexity of defining IK to the indefinable nature of the terms indigenous and knowledge. She further posits that the complexity of defining IK “partly stems from the lack of consensus on who or what qualifies as *indigenous* and also partly from what establishes *knowledge*” (Khupe, 2014, p. 43).

To Kibirige and van Rooyen (2006), IK is local knowledge derived from interactions between people and their environments. These scholars consider IK as a practice of traditional wisdom that is the product of practical engagement with the environment in everyday life. Nevertheless, these scholars recognise that IK is not straightforwardly shared with members of other communities

because of the elements which circulate within a given cultural community (Liveve, 2017). Similarly, Merriam (2018) sees IK as a large body of knowledge and skills that have been developed outside the formal education system, and which enable communities to survive.

Indigenous knowledge systems (IKS) and IK are complex concepts to define (Kauanui, 2021; Ogunniyi, 2007a; Seehawer, 2018a). For instance, Kauanui (2021, p. 14) defines indigenous as “to be born in a specific place”. Increasingly, some approaches to health research and health service provision led by indigenous people are based on indigenous methodologies and experiences. Some approaches incorporate many contemporary and Western developments; yet others prefer a return to more authentic cultural delivery, using traditional medicines and practices such as spiritual and traditional healing approaches (Kauanui, 2021).

Some scholars tend to call IK by different names such as local knowledge, traditional knowledge, IK and traditional ecological knowledge among others (Aikenhead & Jegede, 1996; Ogunniyi, 2007a). In this study, however, I use IK throughout.

2.4.1 What does indigenous mean?

Ogunniyi and Ogawa (2008) refer to indigenous as if it is original or native to a particular place or area. No universal definition is available, as many terms are used to establish what indigenous people know (Hartwig et al., 2021) such as traditional ecological knowledge, local knowledge, IK or science, folk knowledge, farmers’ knowledge, fishers’ knowledge and unspoken knowledge. Hartwig et al. (2021) state that the widely used term, indigenous, is meant to highlight the *autochthonous* nature of this knowledge, but it might overlook knowledge from populations who are not officially recognised as indigenous. The term local can be applied to different geographic contexts, but it lacks specificity. Traditional ecological knowledge is interpreted as a cumulative body of knowledge, practices and representations that describe the relationships of living beings with one another and with their physical environment, which have evolved through adaptive processes and been handed down through generations by cultural transmission (Pukkalla & Sharma, 2021).

Gone and Kirmayer (2020) state that the term indigenous can be unclear because it has various meanings. Its former meaning, as interpreted by colonialists during the colonialism era, is greatly different from today's perception by some of the previously colonised people. In the perception of the colonial masters, the term indigenous was associated with the primitive, the wild, the ignorant and the natural. In this regard, Jackson (2018) argues that the term indigenous presupposes a sphere of commonality among those who form a world collective of indigenous peoples. A commonplace meaning of the adjective indigenous refers to originating or being native to a particular place (Kauanui, 2020).

Kauanui (2020) expresses that the timeframe that qualifies knowledge as indigenous in the African context is if the knowledge existed in pre-colonial times. Through the processes of impositions and adoption, most of the current IK existed in both the Western and non-Western worlds, and various kinds of IK might still exist among Namibians of different ethnic origins, where this study was conducted. The knowledge held by such ethnic groups could be modified over time through social interactions as reiterated by Vygotsky (1978).

Khupe (2014) argues that the lack of accord resulted in the United Nations not adopting a single definition of who is indigenous, but instead compiled a list of descriptors that provide an inclusive understanding of the term, based on:

- “Self-identification as indigenous peoples at the individual level and accepted by the community as their members;
- Historical continuity with pre-colonial and/or pre-settler societies;
- Strong link to territories and surrounding natural resources;
- Distinct social, economic, or political systems;
- Distinct language, culture, and beliefs;
- Form non-dominant groups of society; and
- Resolve to maintain and reproduce their ancestral environments and systems as distinctive peoples and communities” (United Nations, p. 1).

In literature, descriptors⁵ such as aboriginal, native and first nations have been used in the place of indigenous. For instance, in Namibia, the “Land of the Brave” is a combination of a unique cultural heritage, the ancient Khoikhoi and San cultures, mixed with European influences. This was also reflected in, for example, the adoption by some Bantu-speaking people of the click sounds typical of the San language (Franich, 2021). Another example of intercultural borrowings is the existence of certain San racial characteristics and some names of Namibian villages such as *Kaakuwa*, *Ceca*, *Ncamadore* and *Cause*; these are mostly found in Mpungu and other constituencies of the Kavango West Region. I acknowledge that the group of indigenous people in Ukwangali is heterogeneous, because of the influences of trade, political systems, intermarriages and so forth. When using the term indigenous to refer only to people of African descent, this is not to be interpreted as meaning that other racial groups do not have IK (Khupe, 2014).

Carter et al. (2021) argue that indigenous has several usages that differ from being born in a specific place. Such usages tend to define indigenous by experiences shared by a group of people who have inhabited a particular country for a thousand years. Cornassel (2021) affirms the lack of consensus over who is indigenous. To date, every sector such as international organisations, host states, non-governmental organisations and researchers have each attempted to develop their definitional standards of the meaning of indigenous and/or native people.

People can be indigenous because their ancestral roots are embedded in the lands in which they live or would like to live, much more deeply than the roots of more powerful sectors of society living on the same lands or nearby. In the context of this study, traditional *drum making*, *drumming*, *music* and *dance* seem to be part of the society living in the same territory of Ukwangali. To this end, the term indigenous is used to demarcate the boundaries of my study, and to retain the sense of place that IK partakes (Nunes de Lima, 2021).

⁵ The word ‘descriptor’ identifies a subject such as native and/or indigenous based on the context of my study.

2.4.2 What is knowledge?

One more difficulty that comes up in forming a definition for IK is the concept of knowledge. There is no consensus as to what constitutes knowledge. Moving towards a definition of knowledge considers how the terms *know* and *knowledge* is commonly used. Horsthemke (2021) recognises and distinguishes between three main kinds of knowledge, viz. factual knowledge, practical knowledge and knowledge of persons, places or things or knowledge by acquaintance. He argues against the description of any knowledge as indigenous because there is no certainty about the extent to which a framework can be indigenous. I suspect that many if not all, indigenous knowledge projects focus on the second kind of knowledge.

Horsthemke (2021) in developing his argument towards a definition of IK believes that it does not refer to practical knowledge and skills, but rather to knowledge that can be compared with non-*IK*. Moreover, what qualifies as knowledge depends on how societies categorise, code, process and attribute meaning to their experience. That is, the concept of knowledge embraces everyday life and/or prior knowledge, local and national culture as well as an internal and global culture. Children are constantly exploring their social and material environments and learn through communicating with others by playing, experiencing, experimenting with things and reflecting on them (Liveve, 2017). In this regard, Khupe (2014, p. 47) explains that:

Some traditions move knowledge and assemble it through art, ceremony, and ritual; Western science does it through forming disciplinary societies, building instruments, standardization techniques, and writing articles. In both cases, it is a process of knowledge assembly through making connections and negotiating equivalences between the heterogeneous components while simultaneously establishing a social order of trust and authority resulting in a space.

Numerous scholars have asserted the definition of knowledge as something everyone possesses (Chimakonam & du Toit, 2021; Durrant et al., 2021). Chimakonam and du Toit (2021) affirm that African philosophy invites people to take a stand on the issue of reality as experienced by Africans.

Kavango West is inhabited by a Bantu group that lives along the north-eastern border region of Namibia. They possess their African knowledge system to sustain their lifestyle. For instance, their traditional fishing practice, livestock raising and agricultural harvesting for subsistence are ruled by a separate king-*Hompa*. The customs of Kavango West place a lot of emphasis on respect

towards elders who are custodians of cultural heritage and wisdom. Khupe (2014, p. 47) explains that “the noun knowledge is not found in many indigenous languages, and the closest translation is ways of knowing or coming to know”. The second view of knowledge is as a process, and it would be a challenge to test the quality of such knowledge through an external approach. Similarly, Mika (2021), Zagzebski (2017) and Khupe (2014) explain that knowledge is an extremely valued state in which a person is in cognitive contact with reality.

Serenko and Bontis (2021) confirm that knowledge is an intangible resource that exists within the mind of the individual. In addition, knowledge is based on data and information but is always bound to persons and land. Plockey (2015, p. 36) is of the view that the concept of “knowledge is rooted in Western traditions”. Meaning, that knowledge is defined and improved by dominant Euro-American cultures.

Khunyakari (2021, p. 358) defines knowledge as the “process of knowing” and all that it takes for one to acquire knowledge. Furthermore, this scholar emphasises that there are different ways of knowing and knowledge is not only a privilege for the West. There is a proverb in *Ewe*, an ethnic group in Ghana and *Rukwangali* in Namibia and most ethnic groups in Africa which states: “*It is only the child who has not travelled that thinks that it is only his mother’s soup that is sweet*”. All of this attests to the fact that the process of knowing includes all the procedures and/or methods of learning. Knowledge production is not the monopoly of the North or the West (Plockey, 2015). In this regard, Plockey (2015, p. 13) enunciates that:

Knowledge is the whole body of cognition and skills that individuals use to solve problems. It includes theories and practices, everyday rules, and instructions for action. It is constructed by individuals and represents their benefit from causal relationships.

Thus, this means that knowledge is a product of human thought, action and experience. In addition, each culture contains a knowledge base from which its members receive an understanding of the world. That is, knowledge is not the exclusive domain of rich countries, nor the rich in poor countries and it has been acknowledged as one of the most important factors for sustainable development (Plockey, 2015).

Stevens (2008, p. 26) tries to define knowledge by explaining the concept of indigenous and or local as follows:

Indigenous or local knowledge refers to a complete body of knowledge, know-how and practices maintained and developed by peoples, generally in rural areas, who have extended histories of interaction with the natural environment. These sets of understandings, interpretations, and meanings are part of a cultural complex that encompasses language, naming and classification systems, practices for using resources, ritual, spirituality, and worldview. It provides the basis for local-level decision-making about many fundamental aspects of day-to-day life: for example, hunting, fishing, gathering, agriculture and husbandry; food production; water; health; and adaptation to environmental or social change. Non-formal knowledge in contrast to formal knowledge is handed over orally, from generation to generation, and is therefore seldom documented.

Moreover, the definition above takes a step to identify threats to this knowledge and/or the force of domination that undermines it, being formal or Western knowledge. Hence, this study views knowledge as consisting of realistic aspects and processes as well as the values that direct our processes. Below I discuss the term indigenous knowledge.

2.4.3 What is indigenous knowledge (IK)?

Kibirige and van Rooyen (2006) and Schuler and Brito Dias (2021) view IK as a legacy of knowledge and skills unique to a culture and comprising wisdom that has been developed and passed on from generation to generation. Indigenous knowledge (IK) can be comprehended through different dimensions, for instance, agriculture, medicine, security, craft skills – technology, cultural practices, families and linguistics (Schuler & Brito Dias, 2021).

Indigenous knowledge (IK) is local knowledge derived from interactions between people and their environment (Mateus & Ngoza, 2019). Moreover, these scholars consider IK as a form of traditional wisdom which is the product of practical engagement with the environment in everyday lives. Shifafure (2014) describes IK as an all-encompassing knowledge that covers technologies and practices that have been and still are used by indigenous people for existence, endurance and adaptation in different environments. Likewise, IK is local knowledge from which generations of people have directly and indirectly benefitted. The knowledge of indigenous people – that is, indigenous ways of knowing and doing things – has been variably termed.

In the definition of IK, McGregor (2021) notes that IK does not exist in a vacuum and that IK belongs to a community, and access to this knowledge is gained through contact with that community. For that reason, the study interacted with community members – teachers and elders – to explore their skills with *drumming making*, *drumming*, *music* and *dance* to mediate the learning of the concept of sound and other related science concepts.

Indeed, education in Namibia started long before colonisation. At that time, the purpose of education was preparation for adulthood and was done outside the classroom – out-of-school context (Mayana, 2020). It was not the responsibility of a specialist labour force such as teachers, principals, coordinators, consultants or supervisors (Utete et al., 2019). Instead, it was the responsibility of all parents to teach, correct or even discipline a child who did something wrong. The roles and skills of adult society were learnt through poetry, riddles, proverbs, storytelling, memory tests, racing, wrestling, demonstrations as well as traditional songs, dance and games (Utete et al., 2019).

In addition, there was a range of activities children took part in to learn traditional skills. For example, they did carpentry, made drums, built houses and weaved mats and baskets (Kakambi, 2020). Such traditional education was experiential, and a lifelong process and individuals passed through a succession of learning processes in various phases of their lives. It aimed at conveying the people’s cultural heritage, beliefs, behavioural patterns, attitudes, values and skills from one generation to another. In the sense of indigenous media, it has certain features such as:

- the oral tradition of communication;
- to store information in memories;
- information exchange that is face-face; and
- information that is contained within the border of the community.

Hence, IK is not moveable but provides relationships that connect people directly to their environments and the changes that occur within them. Below I discuss IKS.

2.4.4 What is an indigenous knowledge system (IKS)?

Ronoh (2018) emphasises that IKS is an integrated pattern of human knowledge, beliefs and behaviour and comprises language, ideas, beliefs, customs, taboos, rituals, ceremonies, folk stories, artefacts and techniques. Moreover, IKS is a combination of knowledge systems encompassing technology, societal, economic and education as well as legal and government systems. Khupe (2014, p. 49) postulates that:

Indigenous Knowledge Systems are local, community-based systems of knowledge that are unique to a given culture or society and have developed as the culture has evolved over many generations of inhabiting a particular ecosystem. IKS is a general term that refers broadly to the collective knowledge of indigenous people about relationships between people, habitat, and nature. It encompasses knowledge commonly known within a community or a people as well as the knowledge that may be known only to a shaman, tribal elders, a lineage group, or a gender group.

Otulaja and Ogunniyi (2017) affirm that recent lines of research have identified key beliefs of IKS. These comprise the notions that IKS constitutes important natural resources that are unique to a given society and geographical area. In this regard, IKS can be used for the benefit of humankind. Stewart and Bolton (2021) assert that IKS involve analogues that attempt to define and give meaning to the knowledge of indigenous people of a particular society.

2.5 Indigenous Knowledge in Sound Production

Some instruments are used in science classes to demonstrate the production of sound. They produce a sound wave of a particular specific frequency. These various experiments related to sound waves can be performed using a fork, resonance tube and so on. A fork is an instrument that is used by most teachers when explaining how sound can be produced by hitting it in various places. In science laboratories, Physics teachers would consider using a tuning fork or a plucked guitar string which produces sound, but this may be only in well-resourced schools.

On close observation, however, the prongs of the tuning fork or the string are found to have a hazy and blurred sort of cloud outline on account of rapid vibrations. If they are gently touched with the fingers, a series of impulses will be felt. These sensations are nothing but the sound waves. Indeed, the velocity of sound waves in the air at ordinary temperatures is determined using a resonance tube. These experiments can be conducted in class to have a better understanding. Similarly, sound waves are produced in our daily life by hitting the glass with a spoon, pushing a chair and so on. In the context of this study, however, I was interested in how traditional instruments could be used to mediate the learning of sound.

2.5.1 Traditional wooden drum – Ngoma

The drum is known as *ngoma* in the community where the study took place. It is handcrafted using traditional methods and a solid wood frame wrapped with durable African cow or goat skin (Grömer et al., 2017). Similarly, the concept of *Ngoma* is present throughout Eastern and Southern Africa. *Ngoma* refers to the tradition of expression via music, drumming, dance and storytelling; environmental sustainability; transitions; and leadership by using animal representations. History, values, education and even identity can be transmitted between generations. However, the community where the study was conducted refers to *Ngoma* as the diverse types of wooden blow drums, skin bellows and drum bellows that have been in use for traditional purposes.

A wooden drum is generally carved out of a single wooden block. This study sought to understand the community's experiences of traditional *drum making*, *drumming*, *music* and *dance*. That is, how the community from Ukwangali could be used to support Physics teachers in mediating learning of the concept of sound by finding aspects of the drums' fabrication that are used when *making drums*, *drumming*, *music*, and *dance*.

The drum is a significant cultural tool in indigenous cultures for achieving the traditional faith of healing in their community. The African drum is a rhythm instrument that is played during many African celebrations, including weddings and during a full moon (Yudkoff, 2021). Dancing often accompanies the African drum, *ngoma*. Many tuning spears allow for adjusting pitch and sound within an average of 8- or 12-inch diameter of the playing surface. A full drum size produces extremely powerful, warm tones and an impressive bass response. The height and girth make it best suited to full-size rhythmists with a wide stance as shown in Figure 2.1.



Figure 2.1: Drums, drumming, music and dances (Liveve, 2017, p. 68)

A drum wrapped with a thick cow skin gives a powerful and warm tonal sound. A goat's skin is thinner than that of a cow. Therefore, a thick skin vibrates slower and has a lower tone than a thin skin as alluded to in Liveve (2017). A ledge carved for the bottom ring helps keep the drum in place for even sound distribution.

The drum is handcrafted using traditional methods and a solid wood frame wrapped with durable African cow or goat skin (Liveve, 2017; Yudkoff, 2021). Uniquely, the drum consists of two cylindrical bowl shapes. A thin long air duct connects the carved-out bowls, and the bowl is usually covered with a piece of skin – once it is hit with a palm it gives a sound. Each end of the cylinder defines a substantially flat plane.

Typically, the drum's outside has a substantially smooth surface. Furthermore, sound may pass through the cylinder's wall from one end to the other (Gupta et al., 2017). So, the size of the drum depends on the type of dance and the audience who will be attending the ceremony. The skin of any type is treated indigenously using ash. For instance, the skin is smeared with ash from the hardwood leadwood tree – *combretum imberbe-Munyondo* – which only takes two days to dry (Mukwambo, 2017). In addition, the skin is laid flat and stretched during the drying process and secured with wooden pegs. Thereafter, a bark from a tree would then be smeared on the skin, and drenching is done to soften it after disinfecting the skin (Mukwambo, 2017).

Dance is also part of the culture, which is attained and developed through informal education. Moreover, through dance, community members are able to communicate and learn which becomes the hub of knowledge (Durojaye et al., 2021).

In the context of my study, African drumming refers to rhythms that were created or have been adapted to be played in a given society. Western society views these activities as a form of art that is practiced by individuals for the sake of art (Joseph, 2021), whereas Africans see the arts as a communal activity that serves as a means of communication and socialisation, which first and foremost are pragmatic. In traditional African dances, the audience and performer usually belong to the same community (Abbe, 2021).

In Africa, drumming and dancing are social customs that are rooted in meaning and used to strengthen family life, village life and the community. Drumming is done using two sticks, the ends of which are covered with strips of rubber (Skaggs, 2021). Yet, in the context of my study, drumming was done using the palms of the drum masters heating the skin of various stretches.

People come to dance at social gatherings, and friends and relatives dance together in the same ring of dancers. People come from all directions to meet their friends, lovers and relatives, to dance, chat and joke (Nathaus & Nott, 2022). The dance is a community activity in which the whole personality of the dancer is involved in the body movements, a concentration of attention is required, and it reveals their personal sentiments through actions. Skaggs (2021) highlights that the beating of the drums attracts large numbers of neighbours to the homestead of the man who has made himself responsible for the carrying out of ritual duties. Such a crowd becomes the background against which the rites are performed.

Drums speak to all of us including learners and all feel an immediate connection to it once they are struck – its rhythm is our natural legacy. Rhythm exists in the vibration of particles, the cycles of the seasons, the ticking of clocks and the orbit of the Earth. No part of creation is without rhythm. Drums and percussion instruments are progressively accessible, physical, sensory, portable, socially interactive, expressive, cultural and offer a unique visual experience. Someone who has never played a musical instrument in his or her life can pick up a shaker and participate in drumming. Drumming is a practice that spans the globe and has existed in every culture. It has

been used for centuries in rituals, ceremonies, communication, rites of passage, music and dance, celebrations, healing, community building and cultural events (Jankowsky, 2021). Knowledge and information, teaching and learning skills should be combined and the development of an arts education programme should attach value to the importance of traditional African arts while recognising that culture is dynamic and evolving.

Communities relate *drums, drumming, music and dance* to specific days and/or seasonal functions and display distinctive identities amongst cultural groups (Hug, 2021). *Drum making, drumming, music and dance* in communities support interactions through rhyme and melody. Drumming also serves a specific purpose that may express the common values and social relationships of the people in a given society (Mbusi, 2011). Among the Bantu-speaking people of Southern Africa, two diverse types of wooden blow drums, skin bellows and drum bellows are used for traditional practices.

The use of drums and dance in teaching Physics through drumming might assist learners to master the concepts of sound. The concepts of sound relate to many daily phenomena and thus may be considered useful knowledge for learners in helping them to understand their surroundings (Eshach et al., 2016). For instance, learners in Taiwan study the subject of sound extensively for a nationwide entrance examination (Eshact et al., 2016; Liveve, 2017). The Taiwanese curriculum also includes an introduction to instruments like the guitar and *erhu* (a traditional Chinese stringed instrument) (Eshach et al., 2016).

Traditional music and dance in Africa, specifically Namibia, are mostly linked to rituals of social function, as they mediate the orientation of being human, of being moral, to their spirit and conscience and to human traditional and rural life which is transmitted from generation to generation (Tsoubaloko, 2013). According to Tsoubaloko (2013), music and dance are made when infants are named at weddings, at funerals, harvests, coronations, circumcisions-*yovamba*, the transition ceremony after first menstruation-*etembu* and for healings.

Holgate's (2015) study investigated the practice of an Argentine Tango dance community in the East Midlands, England. The local transcultural dance practice was explored to learn about participants' motivations, their experience of and identification with the Argentine Tango and the

meanings produced in the process of their participation. Similarly, in this study, social dancers and Grade 10 Physics teachers as participants were engaged by contextualising the IK of this community of drumming, music and dance as a key methodological strategy in sharing their experience of dancing. All of these lead to an attempt to understand contemporary human life, culture and society that does not take music and dance into serious consideration and thus would be inadequate and misrepresentative.

In the context of my study, artistic and cultural education is central to pedagogy and integrates one of the fundamental tasks of the self-ruled school. Shmachilina-Tsybenko et al. (2021) support this statement that it provides access to culture, heritage and content knowledge, where the different approach is a source of enrichment and allows everyone to observe, experience and understand the biosphere. These scholars accentuate that the school should promote experiences and practices to enable learners to identify, verbalise and conceptualise from the experiences. In addition, DeCicco (2021) supports the teaching of traditional dance as the opportunity to embrace multicultural content in the curriculum and to encourage learners to appreciate and value cultural diversity (Cocks et al., 2012). Dances are dominant in the Ukwangali community of which the Unongo Youth Cultural Group forms part of the community, but there might be some out there that are not yet discovered that are linked to ceremonies, healings, social gatherings and so on.

2.5.2 Northern Namibian musical instruments

Music in Namibia is diverse, probably due to the diversity of language groups and the artificial ethnic separation imposed by the apartheid past which discouraged people from mixing. In the rural northern group, from the coast to the Kalahari and north of the 'red' veterinary border, musical traditions are well preserved. Music and dance are often practiced communally. They relate to specific days and/or seasonal functions and display distinct identities amongst cultural groups (Sadad & Masduki, 2020). Dance serves a specific purpose that may express the communal values and social relationships of the people in a given society (Mbusi, 2011). The use of IK of traditional drumming and dance in teaching Physics might assist teachers to mediate learning of the sound concepts of Grade 10. In this way, learners might find it possible to master the reflection of sound, factors that influence pitch, amplitudes, wavelength, frequency etc.

A set of three drums are used among the Gciriku and Mbukushu people of the Kavango East region and Vakwangali as well as the *Ngangela* tribes such as *Vanyemba mashaka* and *Vasiwokwe* in the Kavango West Region of Namibia. Drumming is combined with clapping and the shaking of reed or grass skirts-*Rudeve*. Among Ndonga speaking people, music and dance are reflected during *Olufuko*. Songs are sung by older women and young women who attend the ceremony. Hence, dance and music in most communities show positivity and support interaction and identity through rhyme and melody.

2.5.3 Storytelling

Storytelling is essentially a trigger that can prompt listeners to pay attention to the message and storyteller. In the context of this study, storytelling is a step toward improving the engagement of the audience. Importantly, stories are critically adopted by audiences who perceive some stories to be more reasonable than others (Bloomfield & Manktelow, 2021). Storytelling in this research allowed both the participants and I to speak freely about all our relationships. Stories might serve as pictures that bring alive and make memorable the experiences of people. Hence, stories and storytelling allowed both researcher-listeners and participants (EMC)-tellers to gain understanding, to do self-analysis and to take new decisions that enabled the sense of ownership during interventions and development of workshop schedules (Chilisa, 2012). So, stories with high wisdom can have internal coherence and external conformity particularly when the story resonates with people's lives. Storytelling involves a two-way interaction between a storyteller and one or more listeners. The responses of the listeners influence the telling of the story. Storytelling emerges from the interaction and cooperative, coordinated efforts of the teller and audience (Kemp et al., 2021). It involves actions; hence actions are the parts of a spoken or manual language other than words, however, not all non-verbal language behaviours need to be present in storytelling (Kemp et al., 2021).

Every culture has a story to tell, and it carries meaning to the audiences. In many cases, teachers begin their daily teaching with a story to connect the content of the lesson, particularly at the foundation level (Nhase, 2019). Storytelling is a practice in indigenous cultures that sustains communities and validates the experiences and epistemologies of indigenous peoples. In addition, storytelling offers opportunities to express the experiences of indigenous peoples in indigenous

languages and fosters relationships and the sharing of IK and cultures (Iseke, 2013). There are many kinds of stories in the community where this study took place, and many uses of storytelling are seasonal. Storytelling happens in many situations, from an open fire conversation to rituals, from telling in the course of other work to performance listeners.

In this regard, both storyteller and listeners sit around the fire to share information while receiving an equal amount of heat as well as equal opportunity to listen to the story being told. Traditionally, all storytelling is done during evening hours. Some storytelling situations demand informality; others are highly formal, while some demand certain themes, attitudes and artistic approaches. At funerals, for instance, elders tell stories that encourage the value of inheriting the orphans rather than materialistic things. During harvesting, they usually tell stories about hyenas (nocturnal) and jackals (clever) to reflect that everyone needs to work hard to enjoy their wealth, not like the characters that appeared in the story. In the traditional court hearing, they tell a story about a couple that had a dispute over their invitation to attend the wedding.

Another aspect of storytelling is as a teaching tool for learning about life. Furthermore, scholars such as Smith (2012) and Seehawer (2018b) maintain that storytelling reflects the orality of many African cultures and is a way of transmitting knowledge. For instance, the Unongo Youth Cultural Group integrates stories and drama whenever they are dancing. The group uses stories and drama to convey messages related to the event to the audience. Stories and the act of storytelling are profoundly important in many indigenous societies (Drawson et al., 2017). Storytelling is a qualitative research method in which participants describe their answers orally rather than on questionnaires, although the relationship and co-creation between the researcher and participants are also considered (Drawson et al., 2017).

2.6 Implications for My Study

As presented in the previous sections, literature offers no common criteria for defining the quality of being indigenous and what qualifies as knowledge. Quite a few factors make defining indigeneity difficult. Similarly, the life of a socio-political system results in changes in the meaning of phenomena with time. It is difficult to come up with a common understanding of what knowledge is when there is no consensus about how we come to know it. In addition, the link of knowledge with power also encourages a cone-shaped tool that possesses knowledge.

For this study, the definition of IK refers to finding factual knowledge and practical knowledge that a community continually constructs from their interactions within given natural and socio-cultural environments. It is from that base that I set out to identify IK in the Unongo Youth Cultural Group in the Ukwangali community that could be used to mediate learning of the concepts of sound in Physics. I consider IK as present-day knowledge which has been shaped by “different kinds of precedent cultures or civilizations” (Khupe, 2014, p. 50). Thus, IK is often revealed in culture, and Bakare and Ojeleye (2020) refer to it as the sum of socially transmitted behaviour patterns, arts, beliefs, institutions and all other products of human work and thought.

My view of IK is not that of an academic construct that is only testable by merit examinations but as action. The lifespan of IK as seen through culture offers complications for incorporation within the school knowledge system which could be reflected in exacting knowledge disciplines. Importantly, this study set to mobilise community members’ cultural knowledge of traditional drums and dances to support grade 10 Physics teachers to co-develop exemplar lessons on sound and other lessons as they confirm how to mediate learning of these.

2.7 The Nature of Indigenous Knowledge

As discussed in the previous sections, the literature presents the evidence that scholars from the Southern African Development Community region and beyond have contributed to our understanding of the nature of IK and to the extent to which IK differs from that of Western knowledge. These scholars focus on both the variety and the common features of local knowledge. For instance, Khupe (2014, p. 50) highlights that knowledge that is described as indigenous is “neither static nor ancient and so must not be treated as a historical artifact far removed from contemporary life”.

It is reasonable to refer to IK in the present moment because it is ever evolving, acculturating other knowledge and technologies (Zwischenberger, 2021). Indigenous knowledge (IK) is socially and historically constructed, always in process and evolving in time. In addition, IK is added to, modified, and sometimes could be destroyed and lost during an interface with knowledge from outside (Mji et al., 2020). Finding knowledge that is purely indigenous to a particular group is scarcely possible. Indigenous knowledge (IK) is embodied in:

Languages, legends, folktales, stories, and cultural experiences of the formerly colonized and historically oppressed; it is symbolized in cultural artifacts such as sculpture, weaving, and painting and embodied in music, dance, rituals, and ceremonies such as weddings and worship. It is the source of literature to draw from to challenge stereotypes of postcolonial societies. (Chilisa, 2012, p. 96)

Instead of relying on written literature, which is often written from a Western perspective, this study assisted in giving *voice* to postcolonial indigenous communities. Indeed, language plays a key role in the transmission of IK (Heinisch, 2021). Through indigenous languages, knowledge has been relayed through generations, as evidenced by the IK that young people and others possess. For instance, in a study of the therapeutic powers of medicinal plants used by traditional healers for mental illness in the Kavango West and East regions of Namibia, Shirungu and Cheikhyoussef (2018) found that the five traditional healers possessed the related knowledge about the power of medicinal plants through oral transmission instead of libraries. The oral transmission of IK in a contemporary, textualised knowledge era has raised concerns about its loss and resulted in calls for documentation for the sake of generations to come as well as for educational purposes (Mavuru & Ramnarain, 2020). Oral transmission presents difficulties when the receiver speaks a different language or comes from a different cultural background.

Knowledge is transmitted by indigenous people from generation to generation orally through narratives, stories, songs and poetry and visually through art paintings, writings, crafts and cultural rituals. Alluding to this way of transmitting IK, Emeagwali and Shizha (2016) postulate that IK is place-oriented and orally transmitted because it is people-centred. Like-mindedly, Mhakure and Otulaja (2017) also suggest that IK is expressed in poetry, drama, proverbs and chants and is carried on from one generation to the other through word of mouth.

According to Mika and Stewart (2017), knowledge can be lost in translation and in the failure to decode language and the behaviour symbols through which IK is stored. It is noted by Mbah et al. (2021) that place-based IK cuts across Western modern knowledge disciplines. Further, these scholars averred those aspects of IK might include, for example, aspects of agriculture, medicine, botany, art and music. The transmission and acquisition of IK often involve demonstrations and imitation.

In the context of this study, knowledge is not learnt for its own sake but for practical and survival purposes (Smith, 1999) to actualise the integration of IK into the teaching of science. The IK embedded in traditional drums and dances is more experiential than it is theoretical, and thus cannot be viewed simply as a product that can be controlled by educational institutions, but as a living process to be absorbed, understood and lived (Eddy & Moradian, 2020). In so doing, the study deemed to seek the role of the inheritance of the cultural wisdom of the Vakwangali community in the teaching of science. Ogunniyi (2007a) indicates that there is a consensus on the definition of IK as the way of knowing and interpreting experiences peculiar or innate to particular cultural groups. Moyo (2021) elaborates that in the South African context, IKS refers to a body of knowledge embedded in African philosophical thinking, and cultural and social practices that have evolved over thousands of years. Figure 2.2 below illustrates a brief explanation of the characteristics of IK for community development.



Figure 2.2: Characteristics of IK for community development (<https://e76f7d1a-a-62cb3a1a-sites.googlegroups.com>)

Mhakure and Otulaja (2017) also define IKS as a body of knowledge embedded in the African ways of knowing and social practices which have been in existence and have evolved over the past years. Moreover, traditional drums and dances seem to have fundamental benefits to science curricula. I draw on the understanding of the nature of IK presented in the literature to shape my approach. It is with the nature of IK in mind that I adopted a participatory approach (Ngcoza, 2007) underpinned by the principles of Ubuntu⁶ (Ogunniyi, 2007a; Ogunniyi, 2018) and informed by the Transformative Model of Education for Sustainable Development (TIMESD) framework, significant to which is designing, implementing and improving IK integrated science lessons (Chikamori et al., 2019).

2.8 Nature of Western Science

Science and/or WS seems to be a system of knowledge like other bodies such as indigenous or local knowledge which relies on certain rules of law that have been established through the application of the scientific approach to phenomena in the world around us. In the the twenty first century, an entirely new global discourse around the idea of science emerged from the society-based knowledge (Strube, 2020).

The Directorate of Education, Arts and Culture (2016) recognises the new meaning of the society-based knowledge which is inclusive of indigenous learners' self-identities. For instance, inquiry, problem-solving and decision-making all takes place within IK, but learners' abilities are attached to a different cultural worldview. Lifelong learning and giving learners tangible interesting of science in the real world are valued priorities in both indigenous and Eurocentric cultures, however, in different culture-based ways.

Advancements in WS play an increasingly significant role in everyday life for indigenous students, but so too does the present-day wisdom of IK in many communities (Mhakure & Otulaja, 2017). It is with this notion that classroom success is a more equitable representation of indigenous

⁶ Ubuntu is an African-centred worldview that emphasises the good-of-all, harmony, mutual respect, relational understanding, interdependence, interrelationships or interconnectedness of all phenomena.

learners in science and mathematics courses and requires more than providing teachers with instructional resources. Exposing both teachers and learners to the role of the Eurocentric and local worldviews would supplement both roles in the learning of science in the NCBE (MEAC, 2016). Indigenous knowledge (IK) fills ethical and knowledge gaps in the Eurocentric education, research and scholarship (Roue & Nakashima, 2018).

The set of scientific realities is nothing but what the scientific viewpoint has created. Science is therefore given to an investigation of the set of realities and also to the system of knowledge obtained as a result of the investigation. In the context of this study, every type of science, be it Western or non-Western, is an art of acknowledgement, whereas technology is an art of creation aimed at improving human life.

Namibia through the Education and Training Sector and Improving Program (ETSIP) seem to simply believe in the applicability of WS to Namibia for a knowledge-based society. One of the most important characteristic features of WS would be that it is inseparable from technology. In that context, the term science plays a similar role as language in fundamental grammar. Science, for instance, WS, is one manifestation of the human ability to articulate the world around us. The general issue of science education is to examine the possibility of translation or interpretation of WS into actual sciences as appear separately. The main Western ideologies and epistemologies (what is acceptable knowledge), ontologies (realities) and axiology (values) infuse over half of the households in the African rural learning curriculum (Dei et al., 2022).

2.9 Worldview

This section describes the key concepts of this study. I give a short overview of how the concept of worldview has been used in various research domains. Thereafter, I focus on the concept of worldviews and teaching.

2.9.1 The concept of worldview

Van der Kooij (2016) states that the concept of worldview has German root. *Weltanschauung* was first used in Immanuel Kant's critique of Judgment in 1790. It seems to refer to the sense perception of the world. It fits the "Zeitgeist" in the philosophy of the emphasis on the "knowing and willing" human as the "cognitive and moral centre" of the universe and became a popular term

(Naugle, 2002, p. 59). The term was developed by others, including Hegel and Goethe, and became a common term in European thought. In his insightful and extensive review of the concept of worldview, Naugle (2002) describe how the term developed and became a familiar term in the work of Dilthey, Nietzsche, Heidegger and Freud, among others. The concepts of philosophy and worldview are closely related, and Chalmers (2016) refers to the term worldview to emphasise a personal and historical point of view.

In contrast to the idea that science is a body of knowledge discovered by scientists working in their laboratories, Weasel (2020) found that community members see themselves as the producers of knowledge. This possibly occurs throughout their daily lives, as men and women are the observers of their environments. There are no special receptionists of knowledge. The elders of the community are the repositories of traditional knowledge (Lavallée, 2009) and they see it as their responsibility to educate the younger members. However, Western culture has interfered with the traditional teaching and learning approach.

Lending support, Alberro (2020) who postulates that, a worldview looks at the person's holistic understanding of themselves, the world, and their place in it. A worldview is culturally dependent and generally subconscious which manifests itself as a set of presuppositions and predisposes one to feel, think and act in predictable patterns. In most cases, a person may not necessarily be aware of what their worldview is; however, their thoughts and actions may alert others to how they view the world. Importantly, such an indicator of a worldview is our set of values, since these values are often influenced by how we see ourselves in the world (Khupe, 2014).

Knowledge and how we come to know are connected to place and people. When I say 'people', I include all people like our ancestors and those who follow us, our descendants. Everything is animate and has spirit, energy and knowledge (Creese, 2021). This understanding leads to seeing holistically. Indigenous peoples are socialised to relate holistically in life, to see everything as a set of patterns as a whole. There appear to be many commonalities between indigenous worldviews. In addition, Ali et al. (2021) explain that indigenous worldviews emerged as a result of the people's close relationship with their environment.

As explained above, the concept of worldviews has been described as mental lenses that are embedded ways of perceiving the world (Ali et al., 2021). Worldviews are cognitive, perceptual and affective maps that people continuously use to make sense of the social landscape and to find ways to whatsoever goals they pursue. The worldview is developed throughout a person's lifetime through socialisation and social interaction. The concept of worldview is encompassing and pervasive in adherence and influence, therefore, it is usually unconsciously and uncritically taken for granted as the way things are. While it is rarely altered in any significant way, worldviews can change slowly over time. Molina-Motos (2019) further clarifies the concept by stating that a worldview defines the self and sets the boundaries of who and what a person is. It also defines everything that is not that person, including their relationships with the human and non-human environments. It shapes their view of the universe and their conception of time and space. It influences their norms and values.

De Oliveira and Nisbett (2017) state that, a worldview is how one views and experiences life. People cannot think about a worldview apart from their socio-cultural context (Mavuru & Ramnarain, 2020) since the social organisation can influence cognitive processes (De Oliveira & Nisbett, 2017; Khupe, 2014).

Khupe's (2014) study conducted in the Mqatsheni community of KwaZulu-Natal in South Africa revealed that there could be worldview differences among African tribal groups and studies tell the existence of the following common worldview characteristics:

- Anthropomorphism (Mbembe, 2021; Williams et al., 2020).
- Collective co-existence and interdependence (Seehawer & Breidlid, 2021).
- Cooperation (Hartmann & Martin, 2021).
- Harmony and avoidance of conflict (Khupe, 2014).

These studies report that collective co-existence and interdependence are the key elements of the African worldview. Furthermore, the individual is deemed as dependent on a group. Part of the contribution of this study to Physics education is an understanding of the worldviews which inform the knowledge of the community of Ukwangali in the Kavango West Region, and how these worldviews relate to school science specifically Physics. Understanding these relationships might inform local science teaching and learning by facilitating a better understanding of how the

members of the Unongo Youth Cultural Group in the Ukwangali community supported Grade 10 Physics teachers to mediate learning of the sound concepts.

2.9.2 Worldview and teaching

Fundamentally, as indigenous persons, we learn from everything – all experiences teach us; plants teach us; animals teach us; water teaches us; people, no matter of what age or gender, teach us (Williams, 2018). In saying so, we are always learning, feeling, thinking and doing – these reflect the entire use of the senses. Essentially, humans learn from what they hear, see and feel, and we know that everything we learn must be put to use for ourselves and others. Such integration would allow indigenous learners to recognise the varied perspectives of multiple worldviews and knowledge, provide an opportunity for intercultural sharing, and allow for a richer understanding of the physical world.

To bring significance to learning in indigenous settings, both teachers and learners should best understand the explanation of natural phenomena if they are to relate them with indigenous terms. Flora et al. (2021) use an example such as when choosing a whirlpool along the river for placing a fishing net, which can be explained initially in the indigenous way of understanding by pointing out the currents, movement of debris and sediment in the water, the likely path of the fish and the condition of the riverbank. The upstream conditions affecting the essential role of the knowledge are being presented. It can then be explained in Western terms such as flow, velocity, resistance, turbidity, sonar readings and tide tables to demonstrate how the modern explanation adds to the traditional understanding and vice versa.

Consequently, all learning can begin with what learners, teachers and the community already know and have experienced in their everyday lives (Flora et al., 2021; Gwekwerere, 2016). With this consideration in mind, this worldview about learning has sought to catalyse and promulgate curricular and pedagogical reforms focusing on increasing the level of connectivity and complementarity between the formal education system and IK system in the communities in which schools are situated. Figure 2.3 below demonstrates the qualities associated with traditional cultural heritage and with WS.

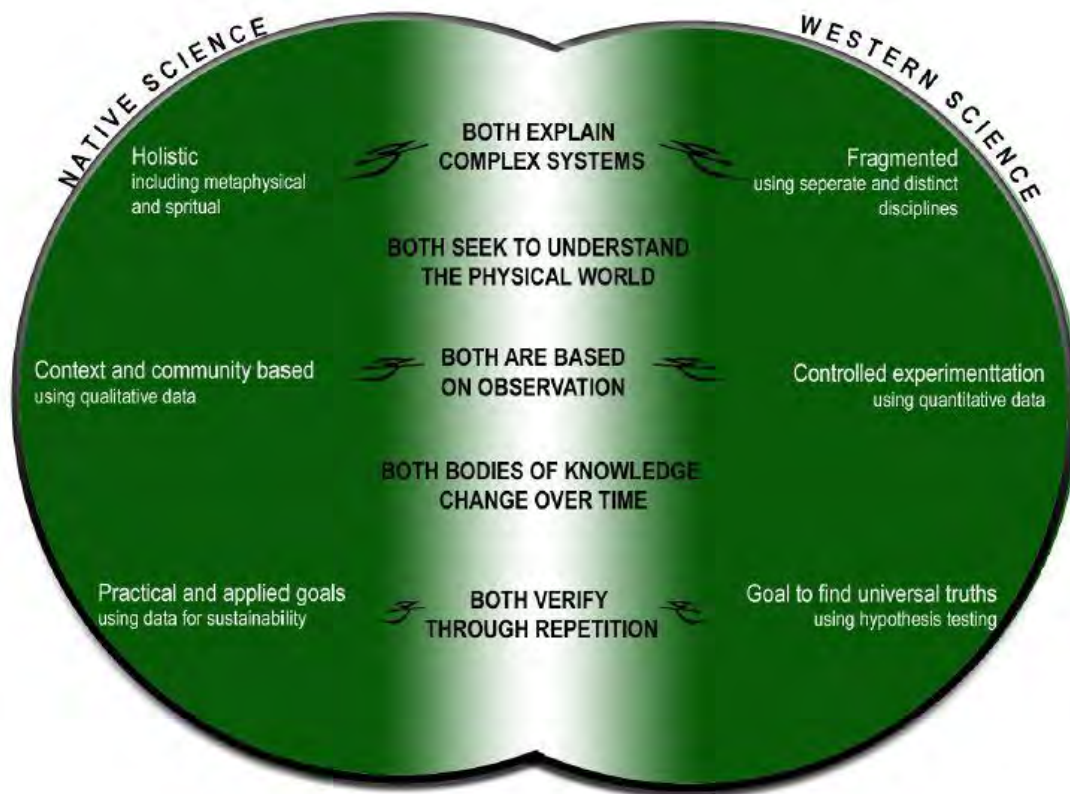


Figure 2.3: Qualities associated with traditional knowledge system and WS (Barnhardt & Kawagley, 2005, p. 16)

This worldview according to indigenous scholars began to identify the epistemology underpinnings and learning processes associated with IK systems (Barnhardt & Kawagley, 2005). Relatively, the significance of linking education to the physical and cultural environment in which learners and schools are situated has a special role to play in indigenous settings where people have acquired a deep and abiding sense of place and relationship to the land in which they have lived for millennia. Most importantly, our worldviews are thought to shape our perceptions and ways of creating knowledge (Khupe 2014). Yet, the science curriculum in many countries, including Namibia, is taught from a Western perspective which is not necessarily the same as the perspective from which many of the learners live.

Similarly, numerous learning theories, for instance, cognitive border crossing (Aikenhead & Jegede, 1999; Aikenhead, 2020), collateral learning (Cunningham, 2021; Jegede, 1995), dialogical argumentation instruction (Ogunniyi, 2011) and social learning theory (Bandura & Walters, 1977) are attempts at explaining the process of negotiating the gap between school science and other knowledge systems with their association with the worldviews. This has important implications for not only identifying IK content that could be used in the Physics classroom but also in discovering how Physics concepts could be taught and learnt in the context both teachers and learners consider authentic, enjoyable and reasonable.

The Physics subject places a strong emphasis on the learners' understanding of the physical and environmental world around them at the local, regional and international levels. It thus includes how societies use natural resources to satisfy their needs (Ministry of Education, Arts, and Culture, 2018). Since independence, the Namibian education system has undergone reforms as a result of this commitment to providing equitable quality education for all. The curriculum was revised to give direction to Basic Education as a crucial step towards the realisation of Vision 2030 and the aspiration of the National Development Plans (NDP1-5) and ETSIP 2005-2020.

The education system inherited from the colonial era was characterised by high failure and drop-out rates of learners (Magudu, 2020), especially in the Kavango West Region where this study was conducted. However, this situation has not changed since the achievement of independence. *Toward Education for All* advocated a LCE approach (Nyambe, 2008; Nyambe & Wilmot, 2012). The LCE is aimed at harnessing curiosity and excitement and promoting democracy and responsibility in lifelong learning. Richmond (2021) contends that the concept of learner-centeredness also relates to the involvement of community members and shared control, accessibility and learner outcomes, assessment and evaluation, course flexibility and collaboration. It is for these reasons that the Namibian context fosters educational goals of access, equity, quality and democracy. That is, it is argued that this system intends to employ a holistic view of learning, valuing life experiences and assisting learners in integrating school life and that outside school.

Physics for the Namibia Senior Secondary Certificate promotes the following aims in the curriculum:

1. To provide, thorough well-designed studies of experimental and practical science, a worthwhile educational experience for all learners, whether or not they go on to study science beyond this level; and
2. To develop abilities and skills those are relevant to the study and practice of Physics and are useful in everyday life (MEAC, 2018, p. 2).

The Physics curriculum in the MEAC in the Republic of Namibia states the general objectives for the learning of the general properties of waves as learners that will “understand the production and transmission of sound and effect of noise on human hearing” (MEAC, 2018, p. 26). Teachers are urged to expose all learners to practical hands-on activities as a minimum requirement and they should be an integral part of teaching and learning. Grade 10 Physics teachers are required to design and describe the production of sound by the vibrating source, how sound moves through the air and how the ear receives sound waves. It thus suggests that teachers should select learning content and methods within the learners’ immediate environment and community as reiterated by Mavuru and Ramanarain (2020).

The NCBE (MEAC, 2016, p. 5) states that “knowledge encompasses indigenous knowledge, local and national culture, and international and global culture”. The integration of the IKS in education, and particularly in science education, has been studied in Namibia, South Africa, India and Japan, and particularly in Taiwan.

It has been observed that teaching of the Namibian science curriculum is mostly done in Western ways which involve the use of Western technology, methodology, materials and the terminology used in science classrooms are Western (Aikenhead, 2020). These approaches to teaching science seem to distance Western African learners as they make learning science abstract, and generally out of touch with the reality of their world (Veiga, 2019). Shankar-Brown (2017) suggests that this feeling of estrangement causes high drop-out of learners from school. Sharing similar thoughts is Mudzamiri (2019) who warns that learners can find it difficult to move between the micro-culture of the family and the micro-culture of the school and this might hamper their success in science.

Indigenous knowledge (IK) allows cultural border crossing from home or community to school science (Aikenhead & Jegede, 1999). Integration of IK into science teaching is seen as a platform to afford discussions on the interaction between Western and indigenous worldviews (Mushayika & Ogunniyi, 2011). Kibirige and van Rooyen (2006) posit that science teaching becomes effective when IK is considered as prior knowledge and as a starting point of learning.

Govender (2014) suggests that African learners seem to learn science abstractly because science is taught without reference to their local or indigenous experiences which in turn makes the learning of science difficult. As a result, the call for the integration of IK into the school curriculum has now found momentum in many countries (Govender & Mutendera, 2020; Mutanho, 2021; Naidoo & Vithal, 2014). In South Africa, for example, under the general aims of the Curriculum and Assessment Policy Statement (Department of Basic Education, 2011) one of its principles is to value IKS. That is, the principal places emphasis on acknowledging the rich history and heritage of Africa in general and South Africa in particular as important providers to nurturing the values which are contained in the constitution.

Hashondili (2020) stresses that science is part of the things we deal with every day. For this reason, as science teachers, we need to find ways to allow learners to share and discuss those everyday experiences and link them with school science. In doing this, learners' motivation to learn science is enhanced which might further boost their performance in science. Lending support, Govender and Mutendera (2020) suggest that for learners to make the most from the science they learn at school, the science curriculum they experience at school must be meaningful and relevant for them to make links with what they experience outside the school doors. That is, the component of learners' prior knowledge as proposed by Mavhunga and Rollnick (2013) plays a role in such attainment of conceptual development.

It is precisely for these reasons that Mahakure and Otulaja (2017) propose the use of culturally responsive pedagogies in science classrooms to make science accessible to all learners from diverse socio-backgrounds (Mavuru & Ramnarian, 2017). For this to happen, though, the science teachers need to have PCK (Mavhunga & Rollnick, 2013; Shulman, 1986). This is evident from Loughran's (2019) argument that no matter how capable or knowledgeable the teacher is in the content, combining both the content and pedagogy is crucial for effective teaching to take place.

This could mean effectively integrating IK with content in the science curriculum to make learning accessible to all learners. In a similar vein, Mavhunga and Kibirige's (2018) study on the integration of learners' knowledge of playground swings established that learners find it easier to comprehend scientific concepts when their IK is integrated into their science lessons. In addition, learners find it easier to comprehend concepts if the teacher develops concepts from the known to the unknown (Mutanho, 2021).

While the curriculum calls for the integration of IK into science teaching, it fails to explicitly indicate how IK could be aligned with the content in the science curriculum. In my view, this failure could lead to science teachers having different perspectives and interpretations of how best this integration could be achieved or failing to include it at all. According to Hewson and Ogunniyi (2011), South Africa and Namibia is not exempt, for example, the situation is fueled by the fact that (1) science teachers have been schooled in a scientific worldview, (2) such kind of schooling produces teachers who have little or no admiration for their indigenous culture, (3) teachers have not been specifically prepared to implement a science-IKS curriculum, and (4) instructional materials, for example, textbooks and teachers' guides on science and IKS are not currently available. This suggests that there is a need for research studies on the integration of IK into science teaching.

For instance, there have already been several studies under the umbrella of Rhodes University, the AASIKS⁷, and SAARMSTE⁸ research programmes on the integration of IK into science teaching in many African countries such as Namibia and South Africa. In addition, this study of mine is part of this research programme. Literature reveals that some science teachers do not include or make use of IK in their science classrooms (Amutenya, 2014; Mutanho, 2021) while some try to integrate IK when opportunities arise (Mukwambo, 2017). Other scholars such as Cronje et al. (2015), Govender (2014) and Ogunniyi and Hewson (2011) highlight that the views that science teachers hold about IK could act as a barrier against its successful integration into science teaching.

⁷ AASIKS-African Association for the Study of Indigenous Knowledge Systems

⁸ SAARMSTE-Southern African Association for Research in Mathematics, Science and Technology Education

To present a topic inclusively, learning units need to be presented using an indigenous perspective before explaining the topic in scientific terms (Kim, 2017). Local IK should be integrated in a holistic way by teachers to connect learners to their natural worlds (spiritually, emotionally, physically and mentally) (Aikenhead, 2020). The use of *drum making, drumming, music and dance* could be one such useful teaching and learning approach that science teachers may apply in multicultural classrooms which learners could link to their everyday life experiences when delivering lessons on the concept of sound. Thus, Grade 10 Physics teachers' professional identity and subsequent teaching practices may benefit suggestively from this collegiality.

2.10 The IK Perspective on Physics Teaching

In Africa, and Namibia in particular, schools are the sites where most learners first experience the interaction between African and Western worldviews (Liu, 2021). It is suggested that the culture of a learner's immediate environment plays a significant role in learning and that it defines how concepts are learnt and stored in the long-term memory as schemata (Müller & Wulf, 2021). Seemingly, WS and IK may be viewed either as dissimilar epistemologies or as harmoniser frameworks depending on whether one views science or knowledge as representations or science or knowledge as performance (Le Grange, 2019). Together *with* the six Grade 10 Physics teachers, we explored opportunities to mediate learning of Physics embedded in the cultural practice of *drum making, drumming, music and dance*. In so doing, Grade 10 Physics teachers and I interacted, participated and learnt during the expert community members' practical demonstrations and explanations on *drum making, drumming, music and dance* for cultural revitalisation and indigenisation of the science curriculum.

The cultural perspective proposed in *drum making, drumming, music and dance* recognises conventional science teaching as an attempt to transmit a scientific subculture to learners (Zhang et al., 2021). Then, cultural transmission can either be supportive or disruptive (Zhang et al., 2021). If the subculture of science generally harmonises with a learner's lifeworld culture, science instruction would tend to support the learner's view of the world. In the field of study, Fortuin (2017) conceptualises the transition between a learner's lifeworld and school science as cultural border crossing (Aikenhead & Jegede, 1999). In the second field, Kim (2017) and Aikenhead and

Jegede (1999) explains cognitive conflicts arising from cultural differences between learners' life worlds and school science in terms of collateral learning.

Once cultural border crossing (from lifeworld culture to school science culture) is difficult for the learner, the teacher needs to take on the role of a tour guide, whereby the teacher takes learners to the principal sites in the culture of science and coaches them on what to look for and how to use it in their everyday lives (Le Grange, 2019). In doing so, the teacher uses an extended repertoire of methods. Equally, if learners experience cognitive conflict when learning about certain phenomena in a science, the learning of science is an incomplete process. For instance, the scientific perspective that lightning, is caused by the discharge of electricity between clouds or from a cloud to the earth might be in conflict with learners' cultural understanding that lightning is caused by, for example, witchcraft (Webb, 2013).

Two strategies may be useful in helping learners to deal with cognitive perturbation or dissonance in this instance (Le Grange, 2007). Le Grange (2019) states that the approach involves arranging learners in small group discussions on questions such as, "is lightning caused by witchcraft?" What this approach does is provide to a small degree, a conceptual ecocultural paradigm that can serve as the basis for the teacher to take on the role of a cultural broker. The second approach is one that was introduced by Aikenhead (2020), where border crossing is made concrete by asking learners to split the page in their notebook in half to form two columns stating, for instance, my ideas and the culture of science ideas. To return to the lightning example, learners would record their ideas and beliefs about lightning in one column, and in the other column what they learnt about lightning in the science classroom. This activity would enable the learners to consciously move back and forth between the everyday world and the world of science (Aikenhead, 2020). It would further enable the teacher to assess learners' recordings and navigate their changing roles of tour guide and travel agent to facilitate learners' border crossings.

2.11 Indigenous Knowledge in the National Curriculum for Basic Education

Calls for a decolonised curriculum in both Namibia and South Africa are gaining momentum (Mukwambo et al., 2014). Indigenous Knowledge Systems (IKS) appreciate and draw from local content and forms of knowing (Hlalele, 2019). This case study is a meta-analysis of the transformation of the curriculum for basic education in Namibia. Thus, it plays role in reviving

colonised voices of indigenous peoples in the teaching of science (Seehawer, 2018). In this study, the integration of IK in the curriculum is one of the reconciliatory practices adopted to deal with the rights of indigenous people globally (Smith, 1999). The integration of IK in the curriculum is one of the reconciliatory practices adopted to deal with the rights of indigenous people globally (Smith, 1999). In Namibia, although the curriculum creates room for IK integration, it seems to continue being characterised by the silent tendencies of continuing a colonial-type curriculum, which is still European and largely excludes local interests and cultural practices. Decolonisation does not mean a total refusal of all so-called Western knowledge; it is rather a coming to know through the view of the researched (Seehawer, 2018; Smith, 1999). In addition, the study sought to decolonise people's minds through curriculum enablement, advocating against the view of IK as inferior and enhancing the teaching knowledge that is relevant for learners' daily lives (Seehawer, 2018).

Moreover, the curriculum has a gatekeeping function in terms of what to allow or not to allow to be passed on to young minds, who are the future of any society. Among others, the curriculum plays an important role in conveying culture from one generation to the next. It is for these reasons that this case study was based on the integration of IK through *drum making*, *drumming*, *music* and *dance* for cultural revitalisation and indigenisation of the curriculum of science in basic education in Namibia and beyond. Such a curriculum reveals quality education that should be delivered through learning outcomes and mediated by skillful, well-prepared teachers that know how to integrate IK.

It is noted that the curriculum documents reflect some confusion about the relationship between IK and WS, both in the wording and in the positioning of examples to science content. The Physical Sciences curriculum development in Namibia has gone through the stages of colonisation, decolonisation and neo-colonisation (Taylor & Cameron, 2016).

For instance, in the Kavango West Region of Namibia, the principle of sound fabrication is applied. Fortunately, the Namibian curriculum does not have restrictions in its curriculum (Mukwambo, 2017). Indeed, it encourages teachers to use local materials which are considered to promote a learner-centred approach. This study strove to create an opportunity for teachers to adapt the curriculum to meet the needs of diverse learners. Sooner or later, when teachers consider the IK of

learners, they accomplish the Africanisation goals set by Mukwambo et al. (2014). Some science concepts elucidated through the indigenous community are explained in the following sections.

2.11.1 Sound waves and echo

In this study, the traditional drums are considered the major source of the sound. Transmission is initially through the skin in forced vibrations. Clark (2021) expresses the standard view that sound is incoherent and is a quality, not of the object that makes the sound, but of the surrounding medium. Possibly, objects do not have sounds rather, they make sounds. To squeak, squeal, wail, howl, and quack – these are all ways of *making* sounds (Clark, 2021).

Scientifically, the sound is made by vibrations that travel through the air or another medium and can be heard when they reach a person's or animal's ear. In addition, sound is a vibration that typically propagates as an audible wave of pressure through a transmission medium such as a gas, liquid or solid. Similarly, a sound wave can be regarded as a transfer of energy as it travels away from a vibrating source. These sound waves are formed when a vibrating object causes the surrounding medium to vibrate (Kadis, 2015; Liveve, 2017).

In this study, drumming was considered as the action for sound transmission through the skin vibration. Scientifically, sounds are the things we hear, they are what we listen to. In the standard view, sounds come from an object, through the air into the ears. To this end, ears are constantly receiving sound (Clark, 2021).

A comprehensive understanding of sound from a Physics perspective implies a close examination of the basic elements of sound waves, namely amplitude, propagation medium and length (Kadis, 2015). The extrinsic manifestations of sound waves are rarefaction and compression and the effects that a sound wave has on materials and how these materials qualify the sound wave are vibrations, resonance and echoes (Clark, 2021). Sound information is transmitted through the medium in which the vibrator is located.

Scientifically, sound waves are longitudinal waves of compression and rarefaction whereby the air molecules move back and forth parallel to the direction of the wave motion centred on an average position, resulting in no net movement of the molecules. Centrally, waves are energy transmitters

that result from a periodic disturbance. The wave described above is a longitudinal type. The vibrations pass through the air, liquid and solid, not the molecules themselves. Sound requires a medium – solid, liquid or air for transmission. Eldridge et al. (2021) affirms that to understand how instruments make sounds and how to use sounds to create aesthetic experiences, learners need to master a few key concepts in Physics, namely propagation medium, amplitude and wavelength, rarefaction and compression as well as vibration and resonance. In my study, the use of drumming enabled teachers to mediate a Physics perspective while having a close experience of the intrinsic elements of sound.

2.11.2 The physics of sound

As stated earlier, sound waves are a transfer of energy in a particular form. Sound is formed when a source is vibrating. When a vibrating object causes the surrounding medium to vibrate, the sound is being made. A medium is a material (solid, liquid or gas) that a wave travels through. When a sound wave moves through a medium the particles in the medium vibrate forward and backward. Scientifically, a sound's volume, (how loud or soft it is) depends on the energy in it; the more energy put into making a sound or a sound wave, the louder the volume will be. In addition, the more energy the farther a sound wave travels before becoming inaudible.

One of the simpler and more common instruments used in a Physics classroom is the string instrument. String instruments make sounds with vibrating strings, and the pitch is modified by the thickness, tension and length of the strings. String instruments can be played in many ways, and come in many variations. String instruments range from the simple to the modern guitar, violin and piano and all of these rely on the sound of strings (Howard, 2014).

Similarly, all string instruments make sounds with tensioned strings. Longer strings produce a lower tone than shorter ones. Tighter strings produce a higher sound than looser ones. Thicker strings produce a lower sound than thinner strings. That is why, even though all the strings on a guitar are the same length, they all sound a different note. String instruments can be plucked, bowed or in the case of the piano, struck. Bowing allows for very long, sustained notes with interesting dynamics. Electric guitars use magnetic pickups to convert vibrations to electric signals. String instruments must be tuned perfectly by tightening or loosening their strings.

2.11.3 Loudness and softness of the sound

Loudness is how our ears perceive a sound wave's amplitude and the larger amplitude is, the louder the perceived sound. Amplitude refers to the magnitude of the sound wave. When the amplitude is increased, the sound gets louder and when it is decreased, the sound gets quieter. The loudness of a sound wave can thus be determined by the amplitude of the sound wave (Kadis, 2015; Liveve, 2017). The minimal loudness of sound perceived by a human is defined as 0dB (20 μ Pa). In general, man's audible frequency range is about 20 Hz to 20 kHz; especially, the frequency range of 2 kHz to 4 kHz is the most audible. For this reason, most piezoelectric sound components are used in this frequency range. Certainly, any sound with a frequency below 20 Hz is known as infrasound, whereas sound with a frequency above 20 000 Hz is known as an ultrasound.

Moreover, it is well known that loudness is determined not only by the amplitude and the frequency of sound but also by temporal factors. To make sure of these results an additional experiment was conducted using auditory evoked potentials (AEP) as a directory of loudness (Schmidt et al., 2020). Amplitude and latency of AEP showed a good correspondence with loudness. Therefore, AEP can be regarded as a good measure of loudness free from subjective biases. The amplitude of a sound wave determines its loudness or volume. Larger amplitude means a louder sound, and smaller amplitude means a softer sound. The vibration of a source sets the amplitude of a wave. It transmits energy into the medium through its vibration. More energetic vibration corresponds to larger amplitude. The molecules move back and forth more vigorously. The frequency of a sound wave is what the human ear understands as pitch. Therefore, a higher frequency sound has a higher pitch, and a lower frequency sound has a lower pitch.

2.12 Challenges of integrating IK

Regarding the term indigenous, Magni (2017) sheds light on the active engagement of indigenous groups worldwide. They have become a symbol of self-identification, self-determination, sovereignty and resilience in the fight for social justice (Smith, 1999). Indigenous groups are, indeed, constantly fighting and lobbying for their right to access their knowledge domains.

Indigenous knowledge (IK) is a living process to be absorbed and understood. Since, it is passed on from generation to generation, factors such as age, gender, experience, political power and occupation influence knowledge transfer (Ye et al., 2020). This may generate different systems within the same community and affect a person's quality and quantity of IK (Ye et al., 2020). Most indigenous groups conceive education as learning for life experience. Thus, they ensure the preparation of the individual to fully become a member of their community through approaches based on learning by doing (Magni, 2017) consisting of observation and actions via interactions with both adult members of the community and the environment. Muluken (2020) addresses that in indigenous communities; women and elders play a special role.

So far, many scholars such as Khupe (2014), Mukwambo (2017) as well as Fakoyede and Otulaja (2019) have acknowledged the importance of IK to address global challenges by explaining its meanings, forms and functions; by understanding how it is put into practice. Unfortunately, research has pointed out that, even in participatory approaches, power relations are still an issue, with non-indigenous populations tending to present themselves as experts in the field and indigenous populations as lacking knowledge (Cockburn, 2015). Therefore, efforts should be made to ensure that the knowledge of all stakeholders involved is treated as equally valid, important and useful. Notwithstanding the benefits discussed, the integration of IK and science in the classroom is not without challenges. IK is sometimes ignored at least in part due to overload (Khupe, 2014) of the traditional curriculum. Differences in the language of modern science and that of IK also present challenges that are further complicated by little representation of indigenous voices among curriculum decision-makers (Khupe, 2014).

Local communities have a complex and highly developed knowledge system. Regardless of their ownership of this knowledge system, it is difficult for indigenous people to advocate for and foster the issues that affect those (Lwoga et al., 2020). These scholars further argue that indigenous communities have been marginalised regarding their socio-economic, cultural and political rights and use of natural resources due to a lack of recognition in national and regional policies. A maddening factor seems to be a lack of representation and participation in decision-making bodies at local and national levels. Below I present the Physics teachers' professional learning community.

2.13 Physics Teachers' Professional Learning Community

If a community is defined holistically as a group of individuals with a shared goal, then each school can be seen as a community (or a series of communities), which in turn encompasses communities of learners and communities of teachers (Wenger, 1998). Professional Learning Communities (PLCs) refer to teachers' critically cross-examining their practices in continuing reflective and collaborative ways to maintain and improve learners' learning (Stoll & Louis, 2008). Both novice and experienced teachers must learn from each other and thus a PLC was used in this study (Vanblaere & Devos, 2016).

Knowledge constructed in out-of-school situations often develops out of activities that: (a) occur in a familiar setting, (b) are predicament driven, (c) are goal-directed, (d) use the learners' natural language, and (e) often occur in a traineeship situation allowing for observation of the skill and thinking involved in expert performance (Lester, 2021). In this study, the professional learning community consisted of six Grade 10 Physics teachers and a science lecturer who facilitated the workshop regarding IK integration. The community engaged in several developmental learning activities. The Grade 10 Physics teachers co-developed exemplar lessons after being engaged in the demonstrations and explanations of *drum making*, *drumming*, and *music and dance* of by the expert community members.

Figure 2.4 below is largely based on the assumption that learning is an individual process that has a beginning and an end that results from doing. This study placed learning at the centre of belonging, becoming, experiencing and doing as stated by Wenger (1998). Wenger (2006) explains that a community of practice has three dimensions or features which are a source of uniformity for the community: joint enterprise, mutual engagement and a shared repertoire. Wyatt et al. (2017) proposed that this learning community is a cultural broker since the participants serve diverse learners who must cross two worlds – one world of formal curricula and instruction and the other of culturally relevant education from cultural knowledge brokers (in this case, the Grade 10 Physics teachers). To effectively cross these worlds, teachers need assistance from “cultural brokers” who I refer to as cultural knowledge brokers (Wyatt et al., 2017, p. 97) who can help make sense of the tension that emerges when these two educational worlds interact – and facilitate the actualisation of the integration of IK into the teaching of science.

In addition, Michie (2014) postulated that a culture knowledge broker in education has attributes of a change agent, mediator and negotiator in order to bridge the two knowledge spaces, such as curriculum science and that of home knowledge. Hence, Grade 10 Physics teachers worked *with* the expert community members to revive cultural heritage and indigenise the science curriculum which is the first dimension of joint enterprise as the cultural knowledge mediators within communities.



Figure 2.4: Components of social theory: An initial inventory (Wenger, 1998, p. 5)

The second dimension of technology is mutual engagement which refers to active collaboration involving such practices as sharing understanding, joint reflection, collective development of new meanings and joint decision-making (Chauraya & Brodie, 2018; Ngcoza & Southwood, 2019). Wenger (2006) raises that mutual engagement fosters coherence in a community of practice and is a source of new meanings and understandings for the community, also called the shared repertoire. The shared repertoire, as the third dimension of the practice of a community of practice which I consider as the stock of knowledge, “includes routines, words, tools, ways of doing things, stories, gestures, symbols, genres, actions or concepts that the community has adopted in the course of its existence, and which become part of its practice” (Chauraya & Brodie, 2018, p. 2). The three dimensions of practice are presented in Figure 2.5 below.

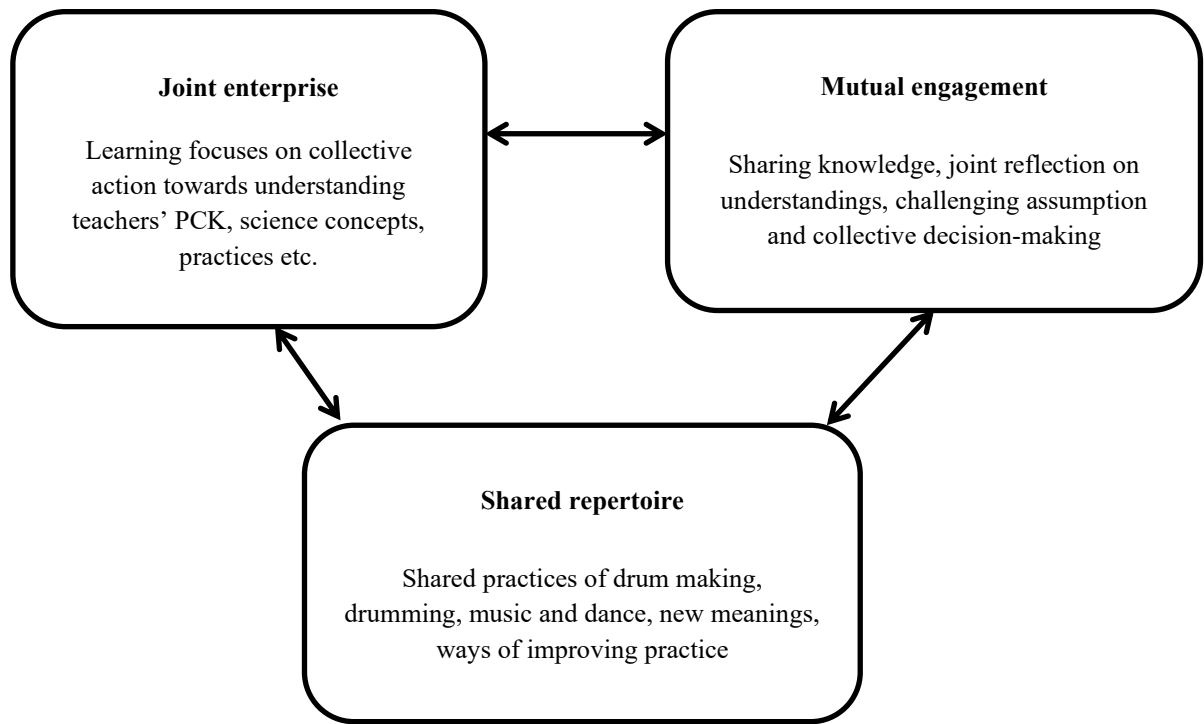


Figure 2.5: Dimensions of practice in professional learning community (adapted from Chauraya & Brodie, 2018, p. 2)

The three dimensions shape each other; hence the double arrows interpret a close relationship with each other that enabled Grade 10 Physics teachers' PLC to reflect what they learnt in those conversations when engaged in the demonstrations and explanations of *drum making, drumming, music* and *dance* by knowledgeable community members. These included the followings:

- Hand clapping is an integral part of music-making in Africa.
- The normative musical function of clapping is to reinforce the emergent beat of music.
- Timeline is a short rhythmic pattern normally entrusted to the bell and played throughout a particular dance drumming.
- Polyrhythm is the “simultaneous use of two or more contrasting rhythms” in a musical texture (Damm, 2017, p. 9).

Scholars such as Wenger (2006) explain a community of practice as formed by people who are engaged in a process of collective learning in a shared territory of human effort. Similarly, it is a group of people who share a concern, a set of problems or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an on-going basis (Smith et al., 2021). The practice is when members develop a shared set of resources for addressing problems in their domain of interest (Noll & Beecham, 2019) as shown in Figure 2.6 below.

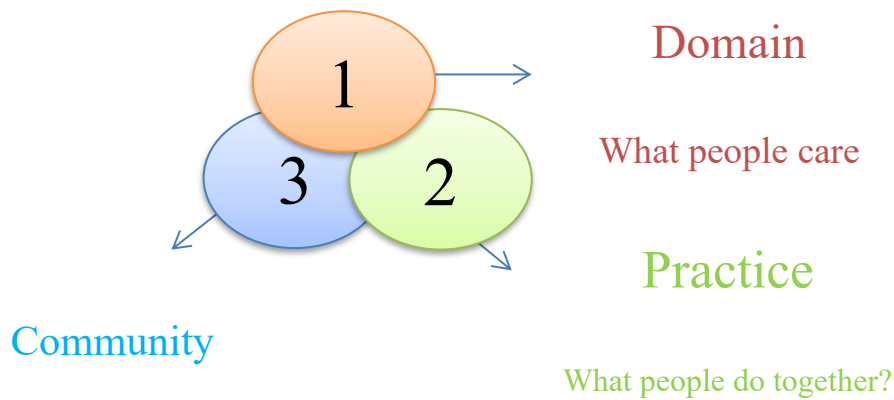


Figure 2.6: Three component of a community of practice (Noll & Beecham, 2019, p. 2)

The domain of human endeavour refers to a tribe learning to survive, a band-group of artists seeking a new form of expression, a group of professionals working on a similar problem and/or a clique of learners defining their identity in the school. Wenger (2006) expresses that the concept of a considered peripheral (CoP) is a group of people who share a passion for something they do and learn how to do it better as they interact regularly which provides different perspectives on knowing and learning.

The CoP forms a collaborative, informal network that supports professional practitioners in their efforts to share understanding and build work-related knowledge (Hartmann, 2020; Ngcoza & Southwood, 2019). Their shared professional identity is the glue that binds members of a CoP together. Undoubtedly, drumming is a practical example of a CoP as a hub for sharing knowledge among Grade 10 Physics teachers involved in teaching the concept of sound and others. Communities of practice (CoPs) are found everywhere. Nearly everyone belongs to a number of

them – at work, at school, at home, in hobbies and some have a name, while some do not. Whatever form each individual’s participation takes, most people are familiar with the experience of belonging to a CoP. A CoP defines itself along three dimensions:

- “What it is about? Its dual enterprise is understood and continually renegotiated by its members;
- How does it function? The relationships of mutual engagement that bind members together into a social entity; and
- What capability it has produced? The shared repertoire of communal resources (routines, sensibilities, artifacts, vocabulary, styles, etc.) that members have developed over time” (Wenger, 1998, p. 2).

Ervin-Kassab and Drouin (2021) also define a CoP as a microsystem where individuals interact to construct the knowledge necessary for them to understand the environment. Depending on the level at which an individual is in a CoP, they can be considered peripheral, inbound, insider, boundary or outbound (Mukwambo, 2017). Peripheral status is given to one who is not fully involved or is a novice in the activities of the CoP (Limongelli et al., 2021). To tie the learning and teaching, it is suggested that bridges for key resources for science teachers such as (a) elder involvement, (b) community contexts, (c) role models, and (d) teaching materials and resources need to be established (Vaugh & de Beer, 2020).

In contrast, not everything called a community is a CoP (Wenger, 2006). Usually, communities develop their practices through a variety of activities. Commonly, the concept of a CoP has found several practical applications in education, business, organisational design, government, professional associations, development projects and civic life. The study adopted a community of professional learning community approach as a way of easing the methods of gathering data. In this study, the concept of a CoP sheds light on a new approach that focused on participants and on the social structures that enabled the participants to learn with and from each other.

Patton and Parker (2017) express several characteristics that explain this interest in CoPs as a vehicle for developing strategic capabilities in organisations:

- Communities of practice enable practitioners to take collective responsibility for managing the knowledge they need, recognising that, given the proper structure, they are in the best position to do this;
- Communities among practitioners create a straight link between learning and performance because the same people participate in communities of practice and teams and business units;
- Practitioners can address the tacit and dynamic aspects of knowledge creation and sharing, as well as the more explicit aspects; and
- Communities are not limited by formal structures: they create networks among people across organisational and geographic boundaries.

From this standpoint, the knowledge of an organisation lives in a collection of communities of practice, each taking care of a particular aspect of the competence that the organisation desires. Particularly, schools and circuits are organisations in their capacity, and they also face increasing knowledge challenges. So, in the circuit where the study occurred, the first applications of communities of practice have been in teacher training. Most importantly, there was a wave of interest in these peer-to-peer professional development activities in the form of the professional learning community. In addition, the workshop and site visits supported deeper learning by providing additional opportunities for constant engagement with the CoP framework. In the CoP framework, PLC members are often positioned as cultural knowledge brokers since they help learners make sense of curricular content and teacher anticipations. In each context, the cultural knowledge broker translates and communicates the important cultural knowledge for learners to move through the educational frequencies (Wyatt et al., 2017). I worked with the Grade 10 Physics teachers on the integration of the cultural knowledge from the community members on *drum making, drumming, music and dance* in co-developing exemplar lessons in their classrooms. The PLC enabled Grade 10 Physics teachers to make use of “culturally relevant, or culture-based, pedagogy”, to link academic content and the background experiences learners bring to classrooms (Wyatt et al., 2017, p. 96). The PLC approach emphasised relationship-building between the Grade

10 Physics teachers, ECMs and me, which could then be extended to the science learners. The ECMs would be able to help teachers identify and address potential concealed biases within themselves, the curriculum and classroom interactions.

2.14 Pedagogical Content Knowledge

Pedagogical content knowledge (PCK) is a theory introduced by Shulman (1986) who contended that for teachers to be able to effectively transform subject matter into teachable units that are easily available to learners, they need to possess expert knowledge which Shulman called PCK. Later, Shulman (1987) introduced the notion of teaching as a transformation of an understanding of subject matter into content accessible to learners (Neumann et al., 2019). More concretely, Shulman (1987) states that teachers' knowledge base must not simply be regarded as a set of professional and experiential skills to be built up. In its place, he argues for a framework that includes and combines content, pedagogy, curriculum and context. For him, teachers' knowledge base consists of different categories of knowledge that are needed for effective teaching. Shulman (1987) further identifies multiple additional knowledge bases needed by a subject teacher as shown below in Figure 2.7.

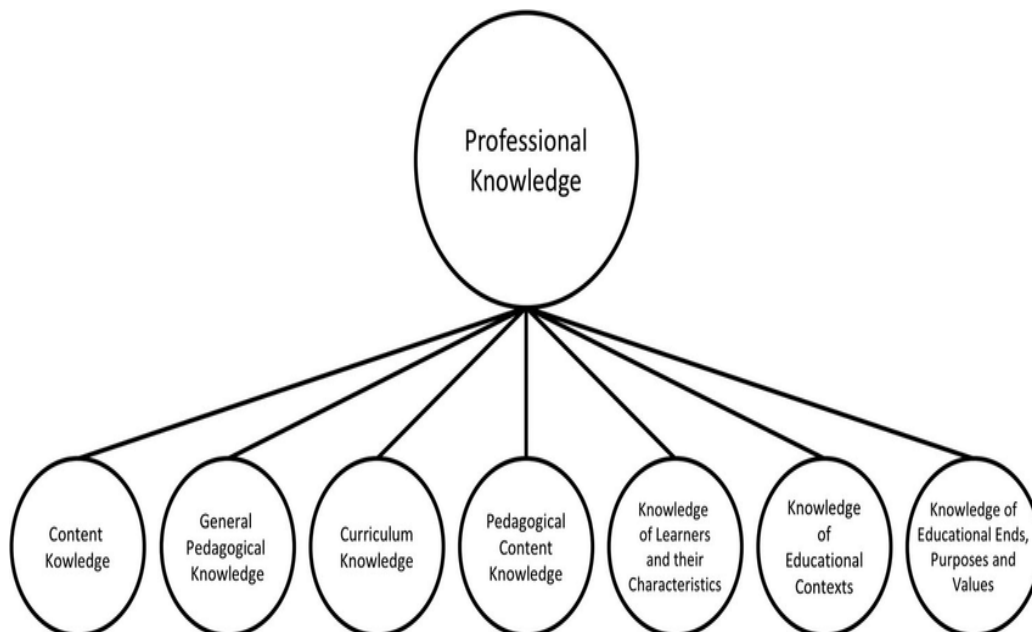


Figure 2.7: Teacher professional knowledge (Neumann et al., 2019, p. 849)

Besides content knowledge (CK) and (general) pedagogical knowledge (PK), these encompass knowledge of curriculum, learners and their characteristics, educational contexts, educational ends, purposes and values and PCK. This knowledge is deemed to be suitable for the Grade 10 Physics teachers when integrating IK into their teaching. Collaboratively, the Grade 10 Physics teachers integrated the cultural knowledge from the expert community members on *drum making, drumming, music and dance* when co-developing the exemplar lessons.

Shulman (1987) highlights PCK as the knowledge that distinguishes a teacher from a content specialist. In other words, PCK is what teachers use to innovatively select the content to be taught, transform it and present it in a simplified manner that makes it easier for learners to understand. In other words, the enactment of PCK is the knowledge that enables the teacher to deliver the real lesson in a way that enables learners to understand the subject matter as reiterated (Mutanho, 2021; Shinana et al., 2021). In Shulman's (1987) view, during that transformation, a teacher thinks through the subject matter as they try to interpret it, simplify and represent it in metaphors, diagrams, pictures, illustrations and other different ways of expressing the ideas in a manner that creates bridges between the learners' understanding and the desired learning outcomes. Moreover, in his theory of pedagogy, Shulman (1987) presents the teacher knowledge categories that teachers should have and denote for successful teaching in their practice.

Reacting to the indefinite nature of PCK, Mavhunga and Rollnick (2013) argued that PCK is topic-specific since a teacher cannot use the same teaching approaches for different lessons and topics within a subject. In clarifying this, Mavhunga and Rollnick adapted the five content-specific components of the TSPCK (see Figure 2.8).

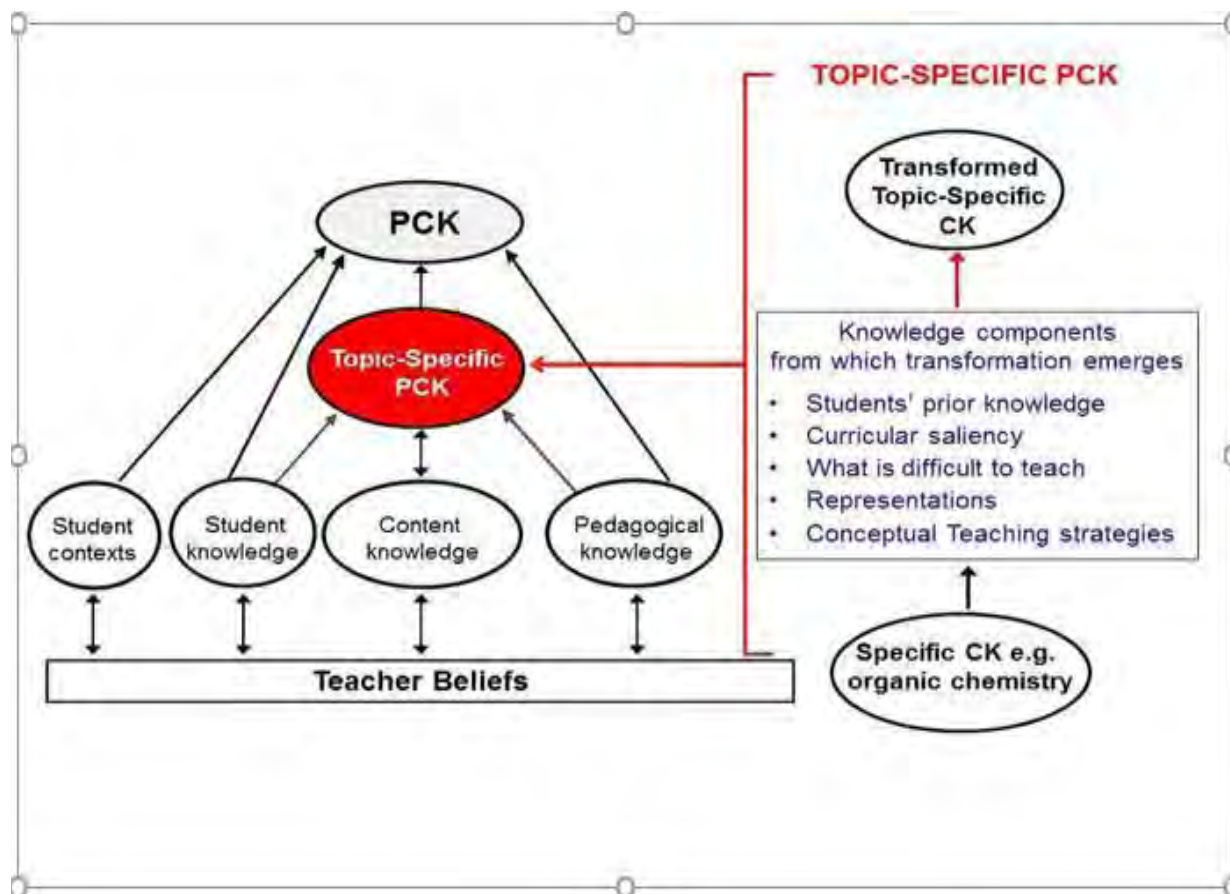


Figure 2.8: A model for TSPCK (Mavhunga & Rollnick, 2013, p. 115)

It comprises both the knowledge of the subject matter, the learners and the context within which the teaching-learning process is taking place (Mutanho, 2021). Hence, Shinana (2019) sees it as the knowledge base for planning a lesson and the actual teaching of the lesson in each session. The purpose of sketching the TSPCK sequences and the nature of teachers' tasks are consolidated in Appendix Y. These are learner prior knowledge (LP), curricular saliency (CS), what is difficult to understand (WDU), representations (RP) and conceptual teaching strategies (CTS). These components were proven to work together to demonstrate a valid theoretical construct (TSPCK) that was assessable through observations. It was hoped that the pedagogical transformation of the content in a topic taught may visually help me to set sophisticated levels of TSPCK.

Visualisation has analogous visibility within the teaching and learning of Physics. Visualisation plays a role in the context of learning and teaching concepts of science in Grade 10 topics. Conversely, learners' difficulties in learning Physics concepts were related to their mental ability which has not been sufficient for associating the representations to CK (Uhde-Stone et al., 2012). Also, Taşar (2010) claims that learning activities should start from the known to the unknown, and/or from the easy to the complex with the aid of the learners' prior knowledge. Models are often used to represent abstract things. Models presented an opportunity to integrate analogies with the lessons on refraction, reflection of sound and thermal energy convection and appear to be a powerful aid to learning in appropriate situations. Notwithstanding, models and representations have to be carefully developed not to constrain learning. That is, Grade 10 Physics learners' misconceptions need to be revealed and corrected to enhance conceptual development (Chauraya & Brodie, 2017).

All five components of TSPCK were important in this study since the teachers were engaged in collaborative activities to enhance both their collective and individual abilities to integrate IK into science teaching, with the definitive aim of transforming their enactment of PCK. I conducted lesson observations in validating Grade 10 Physics teachers' mediation of teaching the exemplar lessons. Appendix Z provides an example of a TSPCK map (Mavhunga & Rollnick, 2016) constructed from the observed lessons of the three Grade 10 Physics teachers to sketch the TSPCK sequences and the nature of teachers' tasks. In most cases, where components were found to be keen and interweaving, they were then presented as overlapping circles. Similarly, where components were found to have a unique sequence, they were represented with solid linear arrow lines pointing out the sequence in which the components emerged in the TSPCK observed lessons. For example, the TSPCK map shown in Appendix Z was interpreted to mean that the observed TSPCK lessons emerged from a response explaining the conceptual teaching strategy to be used. In each lesson observed, the Grade 10 Physics teachers created a teaching sequence and made summaries for most of the major CK in their lessons. In most cases, the observed sequences were completely interwoven setups.

2.15 Chapter Summary

The purpose of this chapter was to review the literature that tackles issues related to the integration of IK in science education. The cultural heritage of *drum making*, *drumming*, *music* and *dance* was used as an example. The literature revealed that there are no common criteria for identifying who qualifies as indigenous and what counts as knowledge. Drumming and dance performances are linked to the core of an exact realm of ideas and beliefs. Furthermore, the literature draws special attention to the definition of IK and its daily life applications. In the context of the study, the practice of traditional drumming, music and dancing signified the parts of IK that a given community would use as ways of communication and learning that mark the end of the day as well as to celebrate the advents of the event. In the next chapter, I discuss the research framework that guided this study.

CHAPTER THREE: THEORETICAL FRAMEWORKS

A theory helps us to select, classify and organize ideas, processes, and concepts. It helps us to explain, clarify and articulate the heart of the issue. Theory helps us to formulate and find causal relationships; it helps us to understand what, how, and why observed phenomena and regularities occur. (Cohen et al., 2018, p.71)

3.1 Introduction

As pointed out in the above epigraph, a theoretical framework in a study is the base used to construct knowledge in research (Cohen et al., 2018; Grant & Osanloo, 2014). A theoretical framework links every aspect of a research study including the research problem, the methodology, data analysis and interpretation (Merriam, 2018). Moreover, Maxwell (2021) sees a theoretical framework as theories, beliefs and prior research findings that guide or inform a research study. In this study, I used Vygotsky's (1978) SCT in conjunction with Ogunniyi's (2007a) CAT as my theoretical frameworks. These two theories were deemed appropriate and relevant to my study as they explained the phenomena I analysed.

3.2 Vygotsky's Socio-Cultural Theory

This study used Vygotsky's (1978) SCT which argues that human cognition is situated in the individual and a cultural setting (Marginson & Dang, 2017). Vygotsky's ideas continue to be influential in educational research. Vygotsky (1978) recommended that culture becomes part of a person's nature, and his work emphasised the individual's interaction with society, the impact of social interaction and language and the impact of culture on the process of learning. Vygotsky (1978) highlighted the role of dialogue in structuring cognition. In other words, he viewed social interaction as the origin of cognitive functions. Vygotsky (1978) argued that social interaction plays a dominant role in influencing the development of the human mind.

The SCT is based on the premise that learning is a product of social interactions involving adults, peers and teachers (Vygotsky, 1978). Ellis (2000) posits that the SCT starts not through interaction but during the interaction. At first, children (beginners) finish a task with the help of another person, learn it, and thereafter can do the same task alone. In this way, social interaction mediates learning.

In the context of my study, practices such as *drum making, drumming, music and dance* were intended to promote interactive arguments and conversations that would help Physics teachers to teach different scientific concepts (Opoku & James, 2020). In this study, I used the following concepts from the SCT: mediation of learning, culture and language, social interactions, ZPD and self-regulation. Each of these concepts is discussed in the following sections.

3.2.1 Mediation of learning

To Rahim et al. (2019), the two theories that have focused on a mediational approach to learning are the Vygotskian SCT (Vygotsky, 1978) and Feuerstein's theory of Mediated Learning Experience (MLE) (Ertit, 2020). The central concept of both SCT and MLE is mediation, and both approaches explore the nature of socio-cultural forces in shaping the learners' development and learning of a given concept like sound in the context of this study. In mediation, participants subsequently develop their identity from being on the periphery to being principal members (Hodkinson & Hodkinson, 2004; Wenger, 1998); from being a novice, to taking ownership in the learning and being an expert. Of interest to me in this study was SCT. At the heart of SCT is the concept of mediation in which a novice develops with the help of others.

Mediation of learning allows teachers to move learners from the known knowledge to the unknown using artefacts (Subero et al., 2018) that were *drum making, drumming, music and dance*. Mediation takes place between two or more people with different knowledge levels on what is to be learnt (Engeström, 2018). Liveve (2017) refers to the mediation of learning as a technique or skill incorporated to explain how knowledge is acquired in the learning process that supports the social constructivist perspective. Concurring, Sugahara and Cilloni (2021) argue that mediation of learning is the connection between the existing states of mental development through the ZPD (Stott, 2016; Vygotsky, 1978).

Learning is a multifarious process in which the learner experiences permanent and lasting changes in knowledge, behaviour and even the ways of processing the world. In addition to this, it is found that learning is very effective when there is collaboration with other learners (Diwan & Srinivasa, 2016). Mediation of learning provides an opportunity for creating this type of learning environment for the learners.

A learning concept is not only content-based (video or text) as seen in most online educational tools, but also has different learning concepts like a discussion forum. Besides, mediation of learning establishes orientations to the professional learning community (see Section 2.12) and how they play out in teachers' education (Orland-Barak & Maskit, 2017) which are strategic, cognitive and socio-cultural. The main elements in mediation are human and symbolic mediators. Hence, mediation has been defined as human or symbolic intermediaries placed between learners and the objects – *drum making, drumming, music and dance* to be learnt, enabling them to achieve higher mental functions so that they are able to later transform their learning proficiencies (Orland-Barak, et al., 2017).

Rahim et al. (2019) further define mediation as a process in which one develops their mental processes during collaboratively constructed dialogic activity by symbolic and socio-cultural constructed artefacts, the most pervasive of which is language. In this research setting, the dialogic activities and social interactions took place between Grade 10 Physics teachers and community members of the Unongo Youth Cultural Group. Hence, culture and language played a vital role in the sense that both groups learnt from the workshop experiences.

3.2.2 Culture and language

As alluded to earlier, in this study the language of communication in Ukwangali is *Rukwangali* and another minority language of Ngangela – *Runyemba*. English is the language of instruction in the participating school; however, it is not often spoken outside of school. Occasionally, *Rukwangali* is used for code switching as a tool for assisting the process of teaching and learning in science classrooms (Ayati, & Widyastuti, 2021). To Vygotsky (1978), the role of language in thought and relationships makes it an important part of educational research, particularly in rural contexts (Khupe, 2014). Hopefully, English might be the 'gateway' to the world outside *Ukwangali*, in which *Rukwangali* underpins the participants' identity expressly the Unongo Youth

Cultural Group. *Rukwangali* is not just the name of a language, it is about culture, as motivated by language. The vaUkwangali culture and knowledge are best understood through the Rukwangali language.

In addition, language is a system of arbitrary signs and is primarily speech (Hartono et al., 2021). Hence, human language is fundamentally creative which would promote language being a mirror of society and its culture. In this regard, language is a reflection of the culture that leads to a longstanding claim concerning the relationship between language and culture (Hartono et al., 2021). It is important, therefore, for educators to be aware of and manage the prior knowledge of learners to mediate the learning process. Language is intimately tied to actions, and this enables the novice to internalise their new learning and develop levels of self-regulation.

Vygotsky (1986) defines culture as a social environment, a system of social standards rather than a mediator of human freedom. Moreover, he sees culture as a way of self-perception of a person, which helps to reveal a creative possibility. In this study, the concept of culture was taken into account in the context of the community members – Unongo Youth Cultural Group – and the instructional language used by the participants both Grade 10 Physics teachers and community members. Culture is both a way of life for people and an agenda within which they make meaning that initiates change (Chilisa, 2012). Seen in this perspective, culture is a set of beliefs and practices which provide opportunities for human beings to be the agents of their destinies (Boykin, 2020).

Culture does not only bring people together but also with it, people become significant to each other. Hence, Vygotsky (1986) defines the concept of culture as something that people create together for each other and therefore it ties them in space and time. One way in which culture has often been understood is as a body of knowledge that people have about a particular society. This body of knowledge can be seen in various ways: knowledge about cultural artefacts or works of art; knowledge about places and institutions; knowledge about events and symbols; or knowledge about ways of living (Stetsenko & Arievitch, 2021). It is also possible to consider this aspect of culture in terms of information and to teach the culture as if it were a set of learnable rules which can be mastered by learners (Bishop et al., 2006). Vygotsky (1978) argues that learning and cognitive development are culturally and socially based. Vygotsky posits that learning precedes development.

To Monaci (2020), cultures within organisations (and other types of social groups) are seen as structured systems that generate self-maintaining social practices. In a similar vein, Gibbons and Prusak (2020, p. 187) employ the concept of “custom” to illustrate how; when an individual is socialised into organisational culture, they reproduce that culture through obedience to the expected habits and routine behaviours. Culture, according to Bishop et al. (2006, p. 5), is that of “practices”; the “shallow” level of culture. Practices are the visible manifestations of culture that reflect the more implicit values and assumptions. Moreover, culture includes: a) symbols (e.g., corporate branding, logos, physical and geographical arrangements); b) heroes/heroines (on whom organisational and/or group members can model themselves and their values); and c) rituals (for instance, weekly meetings or ways of greeting people that are “carried out for their own sake” to maintain social relations rather than to achieve specified objectives) (Bishop et al., 2006, p. 5).

In the context of this study, I refer to culture as the way of revitalising and indigenising the Grade 10 Physics lessons. By mobilising the culture of the learners in a science classroom, cultural border crossing (Aikenhead & Jegede, 1999; Ungruhe & Agergaard, 2020) could be established in the minds of the learners studying the topic of sound. Moreover, culture as a concept is a creative and unifying strength amongst individuals.

Cultural products refer to tangible forms such as artefacts of things and places. Cultural technology involves all the actions that individuals of the culture carry out as part of their way of life, including language. In this regard, cultural perspectives are the explicit and implicit meanings shared by members of the culture such as perceptions, beliefs, values and attitudes. In the context of my study, cultural communities mean the specific groups such as the Unongo Youth Cultural Group, where individuals perform practices in a specific setting; cultural persons indicate the personal way of living a shared way of life through a unique interpretation of the culture.

3.2.3 Social interactions

The main aim of this section is to present a brief overview of our current knowledge of social interaction and engagement. Engagement is a popular concept, both in business contexts as well as in academia. Schaufeli (2012, p. 3), “states that in everyday life, engagement refers to involvement, commitment, passion, enthusiasm, absorption, focused effort”, and energy and all of these are what resulted in the study. Macey and Schneider (2008, p. 4) used a very broad

description of engagement as “a desirable condition that has an organizational purpose, and connotes involvement, commitment, passion, enthusiasm, focused effort, and energy”.

According to Vygotsky (1978), learning is a socially mediated process that starts at a social level. In a social relationship, the learner interacts with their peers and the more knowledgeable others (MKOs). Rubtsov (2016) defines social interactions as the mechanism of sharing functions and a method of understanding those functions. Social constructionism maintains that our knowledge is not derived from the nature of the world as it ‘really’ is; rather, people construct it between them through their daily interactions. Knowledge is, therefore, seen not as something that a person has or does not have, and is neither correct nor incorrect, but is something that people create and enact together.

Our social interactions in this study were capable of producing a variety of possible social constructions of events toward teaching and learning sound and its phenomena. What is regarded as knowledge in this study is, therefore, one possible construction among many. Particularly, the study sought to mobilise the indigenous technology of drum *making, drumming, music and dance* to revitalise and indigenise the Grade 10 Physics lessons such as sound. In this study, Vygotsky’s theory was used as the theoretical lens to understand how teachers co-constructed knowledge and generated new ideas as they engaged in social interactions during the workshops. Of interest, was to understand how such experiences shifted their understanding, in what Vygotsky would call a shift in their ZPD.

3.2.4 Zone of Proximal Development (ZPD)

Vygotsky (1978) defined the ZPD in terms of actual and potential development. The characteristic of actual development is independence (i.e., what the learner can do independently). Potential development is what is beyond the independent understanding or problem-solving abilities of the learner. One of them is the idea of assisted performance, which, although not equivalent to the ZPD, has been the driving force behind much of the interest in Vygotsky’s seminal work. Another convincing feature of the ZPD is that it is in contrast to traditional tests and measures that only indicate the level of development already attained. That is, the ZPD is forward-looking through its affirmation that what one can do today with assistance is symptomatic of what one would be able to do independently in the future. In this sense, ZPD-oriented assessment provides the strength of

mind for both developments achieved and developments achievable (Vygotsky, 1978). The ZPD is the distance between the actual developmental level as determined by the independent problem-solving of an individual and the level of potential development as determined through problem-solving in collaboration with more capable peers (Vygotsky, 1978).

Vygotsky (1978) in his theory of the ZPD observed that when learners were assessed on tasks in which they worked independently, they did not do as well as they would do when they worked in collaboration with peers or adults. Zaretsky (2016) considers the multidimensional model of Vygotsky's ZPD as one of the conceptual tools for helping Grade 10 Physics teachers in promoting their approaches to teaching. In this research, participants (Grade 10 Physics teachers) used the method of reflection and activity approach, a system of principles and techniques facilitating the Grade 10 Physics teachers' development in the course of their collaboration with the community members. The approach relies on supporting the PLC sense of agency in terms of their activities, reflections, awareness, and reforming and construction modes of action (Zaretsky, 2016).

3.2.5 Self-regulated learning

Self-regulated learning strategies as well as goal orientation and intrinsic value, positively predicted the Grade 10 Physics teachers learning about the skills of *drum making*, *drumming*, *music* and *dance* and the science embedded in tanning and warming of the skin. There were some components of the teaching-learning process which had an important role in improving Grade 10 Physics teachers' ability, among others was self-regulated learning (SRL) in mediating science concepts when local knowledge is immersed. Bandura (1991) defined the term SRL as a human characteristic and an ability to observe their behaviour. Then he suggested three phases in conducting SRL, these were:

- to observe and monitor oneself;
- to compare their position with a certain standard; and
- to give either positive or negative self-responses.

The strategy of SRL involved some activities such as self-evaluation, managing and transforming, determining goals and planning, collecting information, noting and monitoring, driving a consequence, thinking of and repeating, seeking social assistance and reviewing some notes (Qohar & Sumarmo, 2013) which this study put in place by allowing the Grade 10 Physics teachers to learn the dances and how to play the drum. This requires SRL behaviour due to the increased autonomy in this teaching approach. Providing Grade 10 Physics teachers with video embedded SRL support (i.e., prompts and explicit instruction) during the learning activities before class proved to be an effective strategy in mediating Physics concepts which promoted the integration of indigenous technologies to enhance teachers' SRL and learning outcomes.

Self-regulated learning (SRL) is achieved through social interactions and begins with the Grade 10 Physics teachers exploring their inner potential to imitate the expert community members' actions through, for example watching the community members' processes on *drum making, drumming, music* and *dance* (Harrison & Muthivhi, 2013). In this regard, the Grade 10 Physics teachers' ability to regulate themselves was essentially linked to social activity, for example *drum making, drumming, music* and *dance*, allowing for thoughtful developmental activity because it provided opportunities to safely test new learning and establish a suitable dialogue. Therefore, I found it befitting to bring in the CAT to complement SCT, since the SCT only provides the explanatory framework that sees learning as a social process (e.g. Lave & Wenger, 1991; Vygotsky, 1978) and authentic (Herrington et al., 2014). The CAT seems to create enough room for users to understand the tensions or contradictions between IK and science. It is for this reason that the learning design of the indigenisation of the science curriculum which was based on the study circle⁹ in each workshop.

⁹ The term study circle refers to a small study group in a learning community. This was also the way how data was validated as was Chilisa (2012) referring to sharing circles.

3.3 Ogunniyi's Contiguity Argumentative Theory

To supplement Vygotsky's SCT, I used Ogunniyi's (2007a) CAT as a lens in this study. The CAT was deemed appropriate in this study as it provided a helpful platform to analyse the Grade 10 Physics teachers' engagements and arguments during the social interactions.

Ogunniyi's (2007a) CAT deals with two cultures that co-exist or conflict, for instance, IK and WS. Ideally, CAT explains potential ways in which conflicts arising from opposing ideas such as in IK and WS can be resolved to reach a meaningful understanding (Ogunniyi & Hewson, 2008). Moreover, CAT, rooted in the Contiguity Theory, is a learning theory visible in the Platonic and Aristotelian eras (Ogunniyi, 2011). To Ogunniyi, CAT has five cognitive states, viz. dominant, suppressed, assimilated, emergent and equipollent. In this study, these five categories were used for describing ways of cognitive co-existence or conflict in multicultural science teaching (Fakudze, 2021). Hence, the following were used when I analysed the data:

- *Dominant scientific worldview*: The Grade 10 Physics teachers' thought system was agreeable to the science concepts presented by the science teacher after being exposed to the explanations and demonstration by the expert community members.
- *Dominant indigenous worldview*: The Grade 10 Physics teachers' thought system decidedly held on to the indigenous worldview and prevailed in the socio-cultural environment regardless of their awareness of the scientific concepts presented in the science curriculum.
- *Suppressed worldview*: The Grade 10 Physics teachers tried to reveal the science conceptions while pressing down their indigenous worldview to complete the syllabus.
- *Assimilated worldview*: The Grade 10 Physics teachers vacated their initially indigenous beliefs and adopted the new science concepts in the teaching.
- *Emergent worldview*: The Grade 10 Physics teachers encountered a new way of looking at a phenomenon.
- *Equipollent worldview*: The Grade 10 physics teachers held on to both indigenous and scientific worldview presuppositions. The Grade 10 Physics teachers expressed their views unashamedly depending on the context in which they found themselves.

The CAT assisted me to determine how Grade 10 Physics teachers mediated learning on the concept of sound after they had interacted, participated and learnt during the practical demonstrations by expert community members on *drum makings, drumming, music and dance*. According to this theory, individuals construct cognitive schemes through interactions and communicating with each other.

In the context of this study, it was hoped that the above-mentioned CAT's five categories would help me to understand both the Grade 10 Physics teachers' and expert community members' views on the integration of IK in the science lessons on the topic of sound in particular. Govender (2014, p. 366) asserts that:

Dominant – a powerful idea seems to explain and predict facts and events effectively; *Assimilated* – a less powerful idea might be consumed into a more powerful one in terms of the persuasiveness of the dominant idea to a given context; *Equipollent* – when two competing ideas have comparably equal intellectual force intensively, the ideas tend to co-exist without necessarily resulting in a conflict.

These five cognitive states of CAT were used as lenses to analyse data emerging from the group discussions between the Grade 10 Physics teachers, community members and myself. These enabled the Physics teachers to see the equal power when different worldviews are interacting together.

Per this theory, individuals construct cognitive schemes through social interactions and communication with each other. Hence, practices inherent in *drum making, drumming, music and dance* in the context of the study were regarded as social activities. Cohen et al. (2018) emphasise that data analysis is the process of organising, accounting for, explaining and interpreting the mass collected data for a specific study. The equipollent cognitive state occurs when two competing ideas have comparably equal intellectual force. That is, the ideas are inclined to co-exist without necessarily resulting in a conflict or dissonance (Le Grange, 2007; Ogunniyi & Hewson, 20008).

The study is situated within a worldview theory as espoused by socio-cultural constructivists. Science classrooms in both junior and senior secondary schools in Namibia are culturally and mostly homogeneous where learners and teachers have a strong grounding in traditional Namibian

culture. In this regard, both the SCT and CAT theories' value was influenced by the worldview's assumptions predominant in the participants' socio-cultural environment (after exposure to *drum making, drumming, music and dance*) (Mavuru & Ramnarain, 2020). Jegede (1995) refers to it as collateral learning, explaining how concepts like nature and nurture, science, predictable, unpredictable, physical and metaphysical, Western and IK science can co-exist in a mental state.

I believed that CAT and SCT were great complementary analytical lenses that would help me as an indigenous researcher to observe the influence of indigenous technologies on pedagogical approaches during social interactions brought about by presentations and explanations by expert community members *on drum making, drumming, music and dance* as well as the Grade 10 Physics teachers in multicultural classrooms. In a nutshell, the CAT of cognition supports the notion that ideas move in and out of various states of the mind, depending on the context of the discourse or argument.

3.4 Chapter Summary

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 seven research processes. The SCT and the CAT were outlined in this chapter. The views of SCT and CAT were internalised as to how they were used to analyse data in this study. The six research processes used to generate the data are discussed in Chapter Four.

CHAPTER FOUR: RESEARCH METHODOLOGY

Research methodology indicates the logic of development of the process used to generate theory that is a procedural framework within which the research is conducted. (Mohajan, 2018, p. 4)

4.1 Introduction

This chapter discusses the research methodology that was followed in conducting this study. Thus, the research methodology of this study refers to the specific procedures and/or techniques used to identify select, process and analyse information about the indigenous technology of *drum making*, *drumming music* and *dance* for cultural revitalisation and indigenisation of the science curriculum. Most importantly, it follows the scientific investigation principles which involved the identification, collection, analysis, dissemination and use of the information or data.

Taking advice from Mohajan (2018) in the above epigraph, this chapter discusses the research paradigms underpinning the study and the research design employed. Within the research paradigm, I discuss the interpretivist case study, indigenous research paradigm and the research design employed in this study.

4.2 Research Paradigms

The term paradigm(s) according to Maree (2018) is a set of assumptions and/or beliefs about fundamental aspects of reality that give growth to a particular worldview. A paradigm consists of the fundamental assumptions and beliefs about the nature of reality (ontology), the relationship between the knower and the known (epistemology) and the set of morals and values underpinning the study (axiology) (Chilisa, 2012).

A research paradigm involves the establishment of protocols that identify a set of accepted procedures which guide researchers in best practices throughout the entire research process (Keskitalo et al., 2021, p.73). Central to this study was building connections, trust and commitment to the research processes. Its focus was on mobilising indigenous technologies of *drum making, drumming, music and dance* and has four important elements which relate to the research paradigm.

- The first is *ontology* or relationships that can exist for a community of agents – that is, the way of being in the world, together with an awareness of the cultural protocols and understandings of the research participants.
- The second is *epistemology*, or how the researcher thinks about reality. This element is essential, as it determines how the knowledge and the meaning of that knowledge are opened including how it relates to concepts such as truth, belief and justification.
- The third, the *research methodology*, serves as a guideline for how I used my thinking when seeking to gain more knowledge about the reality.
- The fourth, the *axiology*, is a set of morals that makes the study a meaningful and safe activity for the research participants involved in the study and regulates how the research benefitted both the participants and me (Wilson, 2001).

Similarly, all research is guided by a set of logical underpinnings. In this regard, van der Walt (2020) explains that a paradigm serves as the lens or set of organising principles by which reality is interpreted (Cohen et al., 2018). In the context of my study, I used the interpretivist and the indigenous research paradigms as complementary paradigms informing how this study was conducted. Each one of these is discussed below.

4.2.1 Interpretivist paradigm

Bertram and Christiansen (2020) explain that an interpretivist paradigm is a “perspective that can lead the researcher to make interpretations with the purpose to understand the method that they choose” (p. 26). Working within an interpretivist paradigm underscores that the world is changeable and that it is people who define the meaning of a particular situation (Bertram & Christiansen, 2020). This study was conducted within an interpretivist paradigm. Clark et al.

(2020) state that the interpretivist paradigm recognises the complexity of the world and acknowledges that reality can only be accessed through social constructions such as language, consciousness and shared meanings.

But these shared meanings are not common across the entire field of search. Relatively, some sense of meaning comes from conversations in the localised present, where researchers interact with their shared experiences from the past and then interface those experiences to their present-day activities while members sit around the fire. In contrast, the interpretivist process creates boundaries for acceptable professional behaviours and reporting story descriptions (Onega, 2017). Educational research from an interpretivist perspective aims to understand the meaning behind human behaviour and how people make sense of their world (Bertram & Christiansen, 2020).

Therefore, social interactions between the interpretivist researcher and participants within their natural setting give rise to detailed descriptions of both researcher and participants from each other within the local context (Mahabeer & Akoo, 2021). Hence, the interpretivist paradigm is deemed appropriate in my study since the participants were teaching in their settings and using the methods and strategies drawn from their experiences and beliefs learnt during the demonstrations and explanations by community members on *drum making, drumming, music and dance*. As already mentioned, the cultural practices were used as cultural tools to revitalise and realise the integration of IK into science teaching.

Notwithstanding, van der Walt (2020) has criticised the interpretivist paradigm because it ends at a point of description and does not give justifications and explanations. I thus complemented it with the indigenous research paradigm, which explains the basic set of beliefs and how these influence the way researchers do research. Also, it enabled us to focus on relational issues such as Ubuntu (Govender & Mudzamiri, 2021; Seehawer, 2018a).

4.2.2 Indigenous research paradigm

After reviewing different research literature, I chose the work of Wilson (2001) as a basis for understanding the indigenous research paradigm. It functions well with cognitive dissonance (Harmon-Jones & Mills, 2019) resulting in a context-based approach (Ulusoy & Onen, 2014). The cognitive dissonance of the participants would be aroused when exposed to indigenous

technologies of drum making, drumming, music and dance to revitalise and indigenise the science curriculum. Wilson (2001) avers that indigenous research reflects indigenous contexts and worldviews. Wilson refers to an indigenous paradigm as:

An Indigenous paradigm that comes from the fundamental belief that knowledge is relational, is shared with all creation, and therefore cannot be owned or discovered. Indigenous research methods should reflect these beliefs and the obligations they imply. (Wilson, 2001, p. 175)

In this section, I discuss the indigenous research paradigm as a framework of belief systems that emanate from the lived experiences, values and history of those belittled and marginalised by Euro-Western research paradigms (Chilisa, 2012). Hence, this study considered the indigenous research paradigm to emphasise holistic, culturally relevant research methods that build on a wide understanding of the connection between the community and the people. The connections were reached through the indigenous technologies of *drum making*, *drumming*, *music* and *dance* to revitalise and indigenise the curriculum of science.

In this regard, a research paradigm is a way of describing a worldview that is informed by philosophical potentials about the nature of social reality. In doing so, the indigenous paradigm resonates well with Chilisa (2012) and Le Grange (2016) who advocated the five phases in the process of decolonisation: “rediscovery and recovery; mourning; dreaming; commitment and action “(Le Grange, 2016, p. 3). It is for this reason that through indigenous paradigm the study sought to rediscover and recover the culture, language and identity of the Grade 10 Physics teachers when participating in the indigenous technologies of drum making, drumming, music and dance. In addition, the paradigm draws attention to the decolonisation phase in which participants invoke their worldviews and IK systems in the teaching of science. A paradigm also has theoretical expectations about the research processes and hence, within the indigenous research paradigm, I focused on the Ubuntu perspective. Ubuntu calls upon us to believe and feel that: “Your pain is my pain, my wealth is your wealth, and your salvation is my salvation” (Nussbaum, 2003, p. 2).

Similarly, Isike (2017), Ogunniyi (2018), Seehawer (2018b), and du Plessis (2019) say Ubuntu is far more than an ethical philosophy; it includes *ontology*, *epistemology*, *axiology*, *spatiality* and a *socio-political* call to action (Keskitalo et al., 2021; Nicolaidis, 2015). Ontology, in the context of

this study, refers to the way community members dealt with the nature and structure of the ‘reality’ of *drum making, drumming, music and dance*.

In most African words, such as Southern Africa Nguni the word “Ubuntu” is used to capture the collective moral belief (Moyo, 2021). In the context of this study, the Ubuntu perspective promoted the philosophy and practice of valuing humaneness towards others and humanism that conceptualises and treats the world as a complex and interdependent ecosystem of humans, nature and the planet (Mbembe, 2021). According to Mbembe (2021, p. 10),

There are many who increasingly believe that, through self-organization and small ruptures, we can create myriad ‘tipping points’ that may lead to deep alterations in the direction that both the continent and the planet take.

Ubuntu means that a person is human through relationships and hence through the playing out of rights and responsibilities to capacitate the community (Hailey, 2008). Within such a perspective, the consequences of research are varied and extend beyond academic enrichment. The researchers joined the community in working together through harmony, and the researchers (who also include community members) become more of a person in the process.

Moreover, one can argue that Ubuntu creates “a spiritual culture” (van der Walt & de Klerk, 2015, p. 278) that has the potential to pave the way for a social set up of cooperation and respect, harmony and peace. Through Ubuntu, I communicated and agreed on the methodology through negotiation with the teachers and community members.

The term Ubuntu has only been recently used in academic discourse but is probably just as old as many African languages (Khupe, 2014). To Khupe (2014), Ubuntu is “a philosophy that sees human needs, interests, and dignity as of fundamental importance and concern” (p. 74). Academic performance on Ubuntu features mostly in the philosophy of education where its value in education and life, in general, has been highlighted (Pansiri et al., 2021). The dynamics of Ubuntu are also seen as having enormous value in the introduction of reconciliation policy in Namibia (Jarrard, 2020).

The study was developed based on such philosophy, the benefiting of African IK and culture. It focused on cultural and social engagements as the best approach to understanding African phenomena (Mkabela, 2005). In identifying the structures of the research, I have suggested Ubuntu as an important worldview through which to explore phenomena (Khupe & Keane, 2017) and in the context of this study, the cultural heritage of *drum making, drumming, music and dance*.

Seehawer (2018b) acknowledges that Ubuntu does not translate easily into Western languages. For instance, in English, it is most often interpreted as “*I am, because we are*”, which seems to suggest that in Africa, individuals exist through community and that what happens to the individual, happens to the whole community. Furthermore, Seehawer (2018b) reflects that Ubuntu includes an element of becoming human and being human (Govender & Mudzamiri, 2021). Equally, elements are realised through lived community and respectful, caring relations with other living beings and the environment. Ubuntu is yet to be established in science education research and Khupe (2014) and Muwanga-Zake (2009) suggest using Ubuntu as a research framework.

Both these aspects relate to the worldview of the community – Ubuntu. Ubuntu refers to an ontology and way of living that have significant differences from those of Western paradigms (Seehawer, 2018b). The focus of the research was on the aspects of the science curriculum that pointed to the importance of Ubuntu.

Research can extend its benefits beyond all those connected to the study. Keane et al. (2017, p. 16) propose that the quality of Ubuntu in research is about “becoming rather than being”. It was extended to the Ubuntu sense of, I become because of you; in relation to you (Keane et al., 2017). Moreover, exploring the cultural heritage of *drum making, drumming, music and dance* resulted in experiential knowing – which according to Keane et al. (2017, p. 16) is “knowing through empathy and resonance, that kind of in-depth knowledge that is almost impossible to put into words”.

In this study, the integration of science and cultural heritage was the prime focus through which the construction of knowledge went beyond academic knowledge. Essentially, the African worldview is embedded in the spirit of Ubuntu focusing on wholeness, community and harmony among African people. Similarly, Moeta et al. (2019) contend that knowledge or science and its

approaches to exploration cannot be divorced from a people's history, cultural context and worldview. As far as African ways of knowing and practices are concerned, African people continue to use these modes of practice wherever they are located (Moeta et al., 2019).

Gavin (2021) claims that African academic systems disseminate Western paradigms and fail researchers who align themselves with African methodologies; such academia seems to ignore them. In the same vein, du Plessis (2019) believes that transformation in research should offer the necessary knowledgeable tools for expressing and exploring the insights of traditional African thinking in a logical way. Also, Ogunniyi (1996) states that research among Bantu, seems to include limiting imported ideas and encouraging local initiatives to create academic independence.

A necessity to transform research among Bantu is motivated by a need to improve the research validity of the process and findings from the research. Among the various kinds of validity, Ubuntu can be used to improve interpretivist validity as detailed below by Muwanga-Zake (2009, p. 416):

- “Technical validity, fit between research questions, data collection procedures, and analysis techniques, and the effective application of specific data collection and analysis techniques;
- Psychosocial validity, the practice, both in the way it is done and in its outcomes in removing Western distortions, restrictions, and rigid norms and values through the adoption of social norms such as Ubuntu;
- Value validity, the evaluation process contributes to valuable personal and social transformation according to the inquirers and participants' views (Heron, 1996) by incorporating into the evaluation Bantu participants' values and discourses (Ubuntu); and
- Fairness, obtaining balanced representations of the multiple realities in a situation by incorporating Bantu values”.

Ubuntu is a Bantu way of being that regulates their relationships, and “Bantu means people” (Muwanga-Zake, 2009, p. 4). In that existence, scholars such as Muwanga-Zake (2009) suggest that Ubuntu defines the individual in terms of rules of conduct in relation to others. Hence, Ubuntu is about good-humoured personal relationships, it highlights the importance of the agreement, and it has the capacity to attain consensus and reconciliation. For Ubuntu as a research perspective or

approach, Seehawer (2018b) identifies Ubuntu-based research with participative research paradigms in which we are bound with others, and the emphasis is on togetherness through cooperation. Thus, Ubuntu implies empowering research participants and emphasising unity in decision-making as well as the procedures that lead to decisions. Essentially, Ubuntu as a research philosophy gives the research process a human face. Within these two paradigms, I employed a case study research design.

4.3 Research Design

After identifying the research question, in all cases, a researcher develops a research design which Bertram and Christiansen (2020, p. 40) refer to as “a plan of how the researcher will systematically collect and analyse the data that is needed to answer the research question”.

Similarly, Punch and Oancea (2014) state that the research design is the basic plan for a piece of research and includes four main ideas that are “the *strategy*, the *conceptual framework*, the question of *who or what* will be studied and the *tools and procedures* to be used for collecting and analyzing” empirical material (Punch & Oancea, 2014, p. 142).

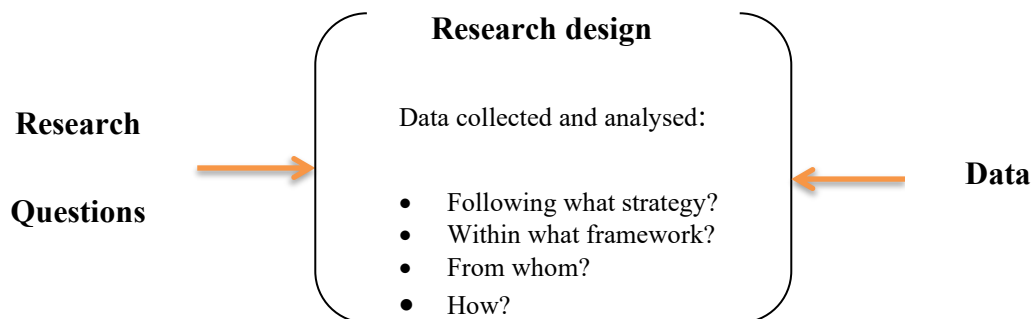


Figure 4.1: Research design connects the research questions to data (adapted from Punch & Oancea, 2014, p. 142)

Research design thus deals with four main questions corresponding to these ideas shown above in Figure 4.1. In this study, I employed a case study research design.

4.3.1 Qualitative case study

In this study, I employed an interventionist case study, central to which was the cultural practices of *drum making, drumming, music and dance* demonstrated by the Unongo Youth Cultural Group as the custodians of the cultural heritage. This resonated well with my study as case studies are employed in educational research to develop an understanding of contexts, communities and individuals and capture the complexity of teaching and learning and the contexts and communities surrounding them (Hamilton & Corbett-Whitter, 2012). A qualitative case study approach was used to understand people or systems within their environment (Arseven, 2018). Cohen et al. (2018) suggest that good qualitative case study research requires in-depth data; in this case, a researcher with the ability to gather data that addressed the mobilisation of the indigenous technology of *drum making, drumming, music and dance* for cultural revitalisation and indigenisation of the science curriculum and to ensure that the integration of IK was attained. To get in-depth data, I used sharing circles as a method of data collection and validation as reiterated by Chilisa (2012) and Lavallée (2009). Sharing circles look like focus groups in that knowledge is gathered through group conversations while sitting around the fire, which was the core methodology implemented in this study.

For this qualitative case study to produce evidence of change through the intervention and to promote learning among the research participants through a context-based approach (Ulusoy & Onen, 2014), it adopted a participatory action approach (PAR) (Ngcoza, 2007; Mutanho, 2021; Seehawer, 2018a) underpinned by the principles of Ubuntu¹⁰ (Ogunniyi, 2007a). Similarly, Keane et al. (2016) and Seehawer (2018a) state that PAR is theoretically situated at the collegiate level of participation and is consistent with the Ubuntu paradigm. Often, researchers recognise the need to integrate local knowledge and experience into research planning and aim for a more collaborative process during field research. Local community knowledge is legitimised in PAR by providing feedback which could be done by oral validation when both participants sit around the fire while sharing the findings of the study. In this regard, participants are active and powerful in

¹⁰ Ubuntu is a social philosophy, a way of being, a code of ethics and behaviour profoundly rooted in African culture (Seehawer, 2018). So, this value pursues to honour the dignity of each person and is concerned about the development and upkeep of mutually affirming and ornamental relationship.

the research rather than passive subjects. Therefore, knowledge is power, with local community members collectively being active and in control (Cohen et al., 2018).

Darby (2017) emphasises that PAR recognises the centrality of power in research and everyday life, and has an explicit memo of gaining power from those elites who hold it and return it to the grassroots, the communities and the mainstream citizenry. In many cases, participatory research methods can be used not only to enable local people to seek solutions according to their priorities but also to co-opt local people into the agenda of others or to justify short-cut research within a top-down process (Cinderby et al., 2021). Below I describe three interrelated features of PAR (Baldwin, 2012, p. 468):

1. *Its participatory worldview* apt the social constructionist argument as people construct reality in relationship with one another as life in society;
2. *The focus on action* and making a difference in how people behave through mind and knowledge; and
3. *The nature of knowledge created through participatory action processes* not just valuing formal theory, but also other ways of knowing and making sense- *experience* the world around them.

Moreover, PAR is a process of knowledge development involving *action* and *reflection*. That is, it is a process of testing knowledge in action and through critical reflection on action. In the context of this study, PAR aimed to solve concrete problems of mediating the learning of sound concepts in Grade 10 and was a vehicle for identifying IK that could be integrated into the exemplar lessons. It sought to make a positive difference in the lives of those involved in the research process and those benefiting from it (Cinderby et al., 2021).

Within PAR, the Dialogical Argumentative Instructional Model (DAIM) was used as a strategic means for negotiating science and IK which aimed at attaining a consensus between the two worldviews if possible (Diwu & Ogunniyi, 2012). It was hoped that after consensus had been reached, the Grade 10 Physics teachers might acknowledge that science is embedded in cultural technologies. Similarly, Ogunniyi's (2007a) CAT highlights that DAIM takes the position that these two worldviews should be equal before the real integration takes place. For the learning of

science to be relevant and meaningful to the learners, Grade 10 Physics teachers need to consider the learners' socio-cultural backgrounds (Mavuru & Ramnarain, 2020). In addition, DAIM indicates that there is potential to assist novices to navigate between their alternative conceptions and those of scientific conceptions. In addition, DAIM also allowed the Grade 10 Physics teachers to participate and engage in arguments through participatory observations. In doing so, teachers were able to ask for further clarifications from the expert community members. In this regard, Langenhoven (2014) postulates that effective instruction creates an environment in which ideas may be raised and contradicted by the evidence and arguments of others. It could be argued that for the Grade 10 Physics teachers to reach optimum levels of critical thinking they must apply dialogical arguments in reaching decisions. To achieve this, both teachers and expert community members (ECM) were using DAIM throughout the six phases of this study as shown in Figure 4.2.

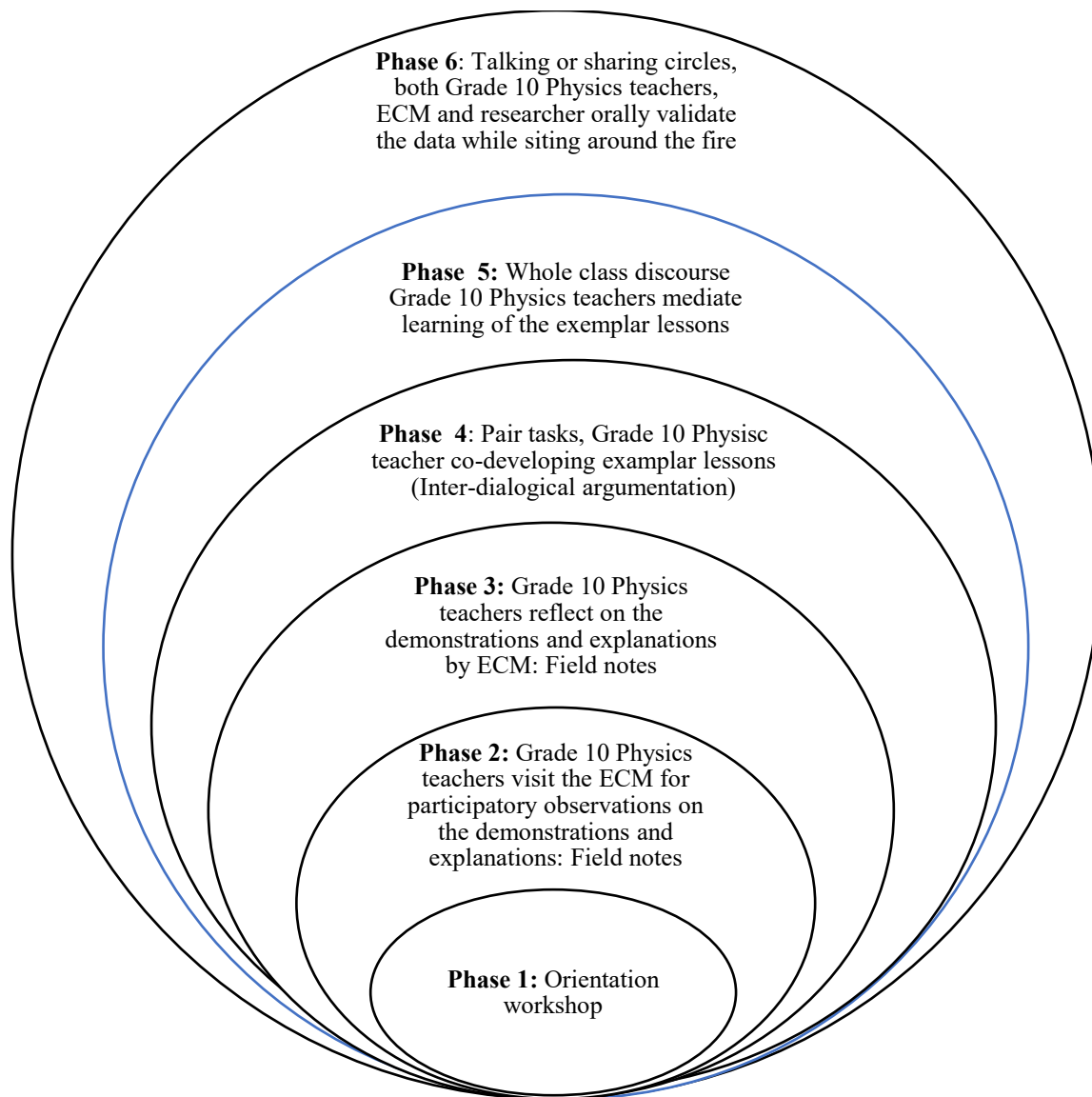


Figure 4.2: Shows the DAIM (adapted from Langenhoven & Stone, 2013, p. 5)

In addition to DAIM, the study was also informed by the TIMSED framework which is significant when designing, implementing and improving IK integrated science teaching (Chikamori et al., 2019). Chikamori et al. (2019, p. 25) explain that the TIMSED framework consists of three learning interrelated sub-processes: “*knowing the present*”, “*past-present relationships*” as well as the “*future-present*”. To these scholars, knowing or studying past-present relationships is referred to as *retroduction*. On the other hand, future-present relationships are referred to as *retrodiction*. In

her study conducted in Namibia, Hashondili (2020) adapted the model to illustrate the process involved in the integration of IK with reference specifically to the traditional ways of preserving foods. Similarly, I also adapted the Transformational model of education for sustainable development (TMESD) framework for my study (see Figure 4.3 below).

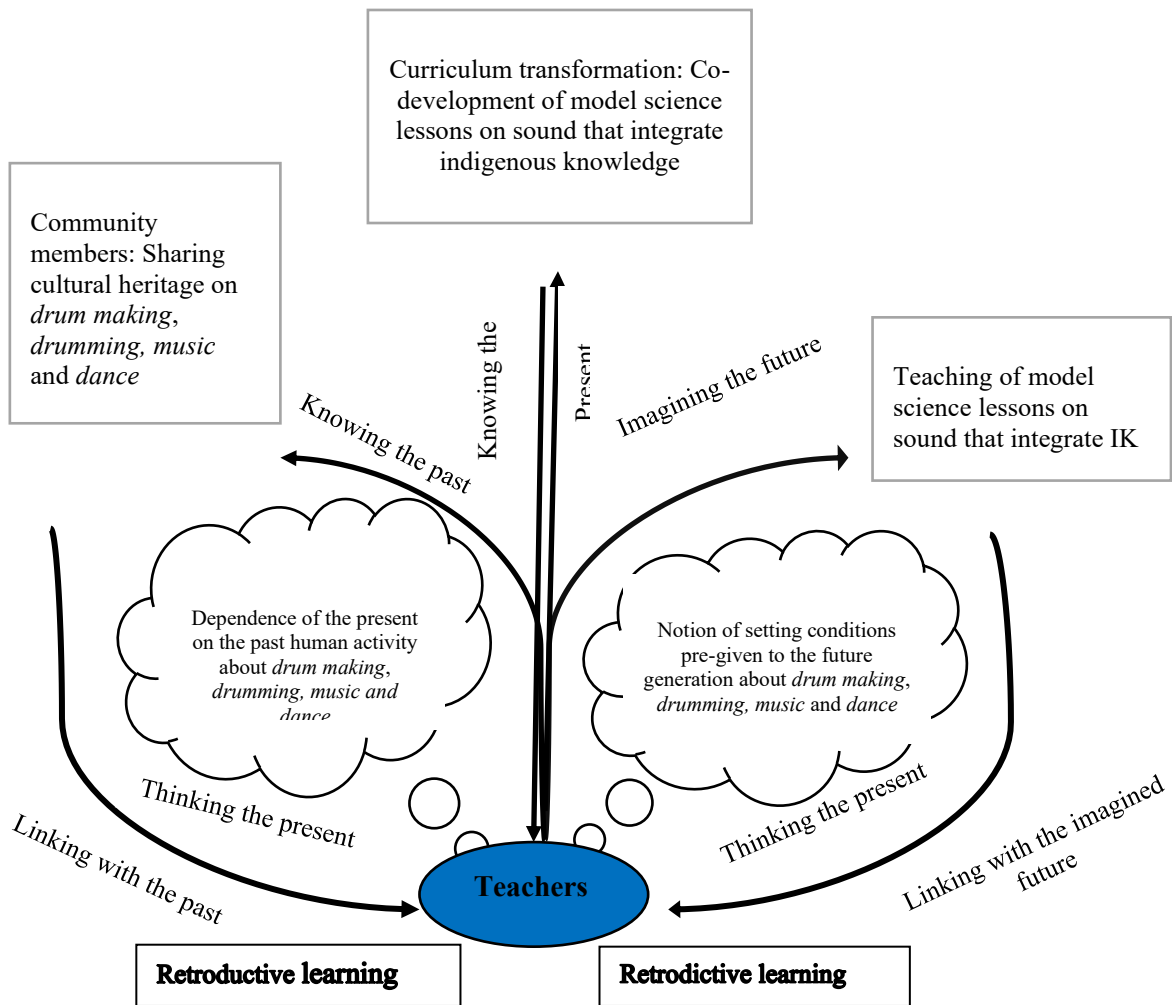


Figure 4.3: Learning process of integrating IK in science (adapted from Chikamori et al., 2019, p. 9)

In the case of my study, science from schools was taken to the community and the cultural heritage from the community was in turn taken to the science classrooms which made learning a belonging and experienced.

4.3.2 Research goal and questions

Research Goal

The main goal of this study was to mobilise the indigenous technology of *drum making, drumming, music* and *dance* for cultural revitalisation and indigenisation of the science curriculum. To achieve this goal, the following research questions were addressed:

Research Questions

1. What are Grade 10 Physics teachers' experiences, pedagogical insights and attitudes toward the use of IK in science teaching?
2. How do the Grade 10 Physics teachers interact, participate and learn (or not) during the ECMs' practical demonstrations and explanations on *drum making, drumming, music* and *dance*?
3. How do the Grade 10 Physics teachers integrate the cultural knowledge from the ECMs on *drum making, drumming, music* and *dance* when co-developing exemplar lesson plans?
4. How do Grade 10 Physics teachers mediate learning during enactment of the planned exemplar lesson in their classrooms?

4.3.3 Research site and selection of participants

The study was conducted in the Ukwangali community in the Tondoro constituency of the Kavango West Region (see Figure 4.4) below, where Nkurenkuru is the regional capital about 570 km from Windhoek the capital city of Namibia. Ukwangali neighbours the Oshikoto and Otjozondjupa regions in which Mangetti National Park is the border. Moreover, Ukwangali forms one of the two main areas of the Mangetti complex of 1) Kavango Cattle Ranch, a parastatal farm company on its West and administered by the Namibia Development Corporation in the Kavango West Region of northern Namibia. This is a working cattle ranch with more than 17,000 head of cattle by the time of the study; 2) Mangetti National Park is a protected wilderness area to the east which is home to many antelope and predator species. In addition, it is an area of more than 2000 km² of north-eastern Kalahari woodlands and mixed acacia savannah.



Figure 4.4: The map of the Kavango West Region with the Tondoro constituency where the study occurs (adapted from <https://r.search.yahoo.com/>)

Bertram and Christiansen (2020) explain that sampling involves making decisions about which people, settings, events or behaviours to include in a study. They add that researchers need to decide how many individuals, groups or objects (such as schools) are to be observed. For my research study, I worked *with* six Grade 10 Physics teachers from three schools in the Kandjimi Circuit and a university lecturer as my critical friend. My critical friend's role was to facilitate the workshops on the integration of IK into science lessons as the Unongo Youth Cultural Group demonstrated and explained the different facets of *drum making*, *drumming*, *music* and *dance*. In this study, I use the term Unongo Youth Cultural Group and the ECMs interchangeably.

The sampling was purposively selected on the basis that I chose these teachers for various reasons as highlighted by Bertram and Christiansen (2020), namely at the time of this study, only five teachers were teaching in historically disadvantaged public schools where there was a lack of resources, whereas the other one was teaching at a well-resourced school in an urban area. They

had also witnessed the curriculum changes in their teaching areas of expertise. All had a minimum experience of three years teaching Grade 10 Physical Science. In addition, Kaurungi was a Grade 10 Physics teacher who was assigned to train learners in cultural music and dance to prepare learners to partake in cultural school competitions for the third trimester of each academic year. Ala-Jääski and Puumalainen (2021) argue that choosing a sampling method that will help answer the question the researcher is interested in is of utmost importance. It was also interesting to observe how these teachers went about designing, planning and delivering teaching that integrated IK, for instance into the science lessons on the concept of sound to the selected Grade 10s after the intervention.

4.3.3.1 VaUkwangali¹¹ identity through dance

Traditional dances in the vaUkwangali community of the Kavango West Region, just like in most Namibian societies, remain some of the most spectacular practices since time immemorial. Wigs-*Yihiho* made of beads of different colours, their waists in skirts made from reeds called *Rudeve*, belts-*Ekondambunda* made of twisted beads and their ankles covered in rattles made from wild dry acacia bean seeds, complete a dancing kit for both young and old dancers of vaUkwangali communities.

Notably, during *Ukambe*, dance performers clap their hands as they sing traditional songs. Similar to most Namibian and other African traditions, dancing is emphasised, and movement is considered an important way of communication. For this purpose, the dances use symbolic gestures, mime, props, masks and other visual devices. Carrying different symbolic items such as traditional baskets, traditional brooms and wooden guns, they shake their waists and shoulders as they sing and position themselves in linear, circular, bending columns of two or more rows.

Ukambe is a historical dance performed by housewives as they welcomed their husbands upon return from their hunting missions even if they did not kill any animals, to show that they were welcome back home. The songs were accompanied by the drums, usually played by boys or men

¹¹ vaUkwangali is a native or inhabitant of Ukwangali/adjective relating to or characteristic of Ukwangali

made from hollowed tree trunks and animal skins. These drumbeats were mainly used to arouse the attention and reaction of those dancing as well as the audience. In harmony, the drummer and the drum created patterns of consciousness that gave moments of stimulus to those around them.

Songs were usually performed in harmony and sometimes in call-and-response form. The basic movement could be simple, emphasising the upper body and feet or it may be complex involving coordination of different parts of the body and complicated actions such as fast rotations, ripples of the body and contraction and relaxing of stomach muscles. The dance may be open to all, or it may be an activity in which one, two, three or four individuals regardless of sex take turns in the dancing ring. Also, during the *Ukambe* dance, men carrying meat would ride on horses and dance. Their waist dance was an imitation of what horses does while galloping.

Unfortunately, owing to urbanisation and the impact of Western culture, traditional music and dance although still practiced, have been taken lightly in many parts of Africa and Namibia is no exception. The dance has equally evolved to suit today's world. While the dress code remains the same, the dance or waist movements are performed faster whereas before they were in slow-motion. Moreover, the songs suited the events of that time but today, new themes have been added to accommodate the needs of the modern world. However, the musical expressions have not changed at all. Undeniably, the songs are used as an avenue of communication. For *Ukambe* dance, there are also varieties of cultural dances performed by vaUkwangali communities, namely *Kambamba*, *Epera*, *Ukambe* and *Nondere*. While *makisi*, *matusu*, *unyanga*, *kazambi*, *ndowa*, *makopo* and so forth form part of the Ukwangali cultural concerts of the minority ethnic groups of Ngangela – *Vanyemba mashaka*, *Vankangala* and *Vasiwokwe*. The above dances are performed seasonally and often during certain functions such as weddings

Traditionally, *Epera* is the Rukwangali term for the celebratory and/or harvest dance which is done by both sexes of all ages, with men and women standing in rows facing one another. It is accompanied by three drums, singing and clapping. The performance took place in an open space or ground, with the performers dressed in colourful attire. Three drums of different sizes are played by men who were also involved in the dance (<https://youtu.be/d0Mp4lsi7gU>). *Epera* dance consists of relationships between movements as they occur in space and through time. Thus, dances have a spatial (visual) design as well as a time design (Charbonneau et al., 2009). The time

design relates to the aural aspects of music, to performance time, to relationships- in time between dancers. The spatial design includes the ground plan, the shapes, and modalities of the dance (Charbonneau, et al., 2009).

The Ukwangali Community: The chief is usually the one given the throne, but they should be from the royal family. The royal family was in the Ukwangali tribe referred to as the “Hyena clan”, but the “Hyena clan” was divided into two smaller clans, there were those who would never become chiefs (mainly due to their paternal blood), known as the slave hyena clan and those who were entitled to become chiefs due to their maternal blood relation. It was only for the “royal Hyena clan-those that was entitled to the throne that a tribal leader was taken from” (Nambadi, 2007, p. 23).

At the time of the study, the Ukwangali community was one of the 49 officially recognised traditional communities with its customary laws and traditions in Namibia where the Unongo Youth Cultural Group resided in the village called Yinsu. Ukwangali is one of five communities in both the Kavango West and East region, viz. Ukwangali and Mbunza being in the Kavango West whereas, Shambyu, Gciriku and Hambukushu are found in the Kavango East region. Ukwangali is associated with the Vakwangali tribe, the first people who migrated from *MakuzugaMuntenda* in the Cuando *Cubago* province of the southern part of Angola and settled in the northern part of Namibia in the Kavango West Region in a place called Ukwangali. Below I present information on the kingdom of Ukwangali and its locality.

Ukwangali Traditional Authority and Natural Environment: Chieftainship-*Uhompa* in Kavango West-*Ukwangali* was deeply embedded in tradition (Nambadi, 2007). Chiefs-*Hompa* in Kavango West were never government appointees or through electorates before or even after the colonial occupation of Kavango West by both German and South African occupation (Nambadi, 2007). Instead, the occupation of a throne by an individual was based on traditional customs and traditions of their tribes.

Since 1700, Ukwangali Kingdom had produced twenty kings and three queens of whom six were females, not quasi-leaders but true leaders. Interestingly, the Ukwangali kingdom in the early days of the 17th century was ruled by queens in successive years from 1750 to 1886. According to the genealogy of the Ukwangali kings and queens; queens ruled in the following order: Mate I ruled from 1750-1775, queen Nankali from 1775 - 1784, queen

Simbara from 1785-1800, queen Mate II from 1800 – 1818 while queen Mpande 1880-1886. (Katewa, 2016, p. 55)

However, during the time of my study, Hompa Eugen Siwombe Kudumo was the current leader of the vaUkwangali Royal in the Kavango West Region of Namibia. His coronation as chief of the vaUkwangali took place in 2015 following the demise of his grandfather Daniel Sientu Mpasi on 17 December 2014 and he is the 21st hompa of the vaUkwangali. The tensions between Hompa Daniel Sientu Mpasi and Ukwangali Traditional Anti-Corruption Advisors have persisted to the current administration of Hompa Kudumo. Hence, Siteketa and 22 other applicants in the matter maintained throughout that those vaUkwangali elders were supposed to evaluate four candidates from different royal families to choose the late Sientu's successor. In his mission to stop Kudumo from being crowned, Siteketa wrote a petition to the then Minister of Regional and Local Governance, Major-General Charles Namoloh (Rt.) seeking to appeal, but this did not materialise as Kudumo got the chieftaincy.

Hompa then had to appoint distinguished senior chief councilors-*Marenga* from the greatest councilor-*Masimbi*, and from house-heads-*Vanturagumbo* who are individuals with extraordinary skills and knowledge from their respective communities regardless of their sex and clans, to administer the Ukwangali Traditional Authority with him. Certainly, decisions or judgments passed at the lower tribal courts headed by different *Marenga* and *Masimbi* of particular villages requires the chief's knowledge and some decisions cannot materialise without the endorsement of the chief – whereas other decisions for minors could be achieved by the lower courts and only required the chief's knowledge. Hompa has authority over all residents that live within his tribal traditional boundary and is also the custodian of the land.

Because most community members do not have national identity documents, they could not benefit from social grants which are called "Harambee", simply because it was introduced during the time of the Harambee Prosperity Plan programme and Emergency Income Grant. Hence, most of the vaUkwangali have survived by subsistence farming, and natural resources have been utilised in many ways such as wood carving, hunting and fishing for a living and to honour their wooden drums during their rituals.

4.3.3.2 Unongo¹² Cultural Youth Group: The ECMs

Expert community members (ECMs) are an important part of indigenous culture because of the traditional knowledge that they teach. They carry the traditional teachings, the ceremonies and the stories of all our relations. Therefore, for research to be based on IK, community members need to be included (Arsenault et al., 2019). These communities, for example, Ukwangali, have a council called the Ukwangali Chief Council to act as advisors to such communities. Researchers usually address the chief council and/or community leaders before doing research with the community.

The Unongo Youth Cultural Group is a cultural group from the Kavango west region based in the Yinsu village of the Ukwangali community. Yinsu is a rural area with a few buildings belonging to the state during the time of the study. There are also schools or hospitals as well as mini supermarkets called *Check-In* that employ local people. It is one of the best cultural youth group categories in the circuit, region and nationally. The humble beginnings of the group were based on empowering the youth with cultural norms and embracing the Kavango culture through drama and dances. The Unongo Cultural Youth Group acquired this by approaching traditional and political leaders, elders and school managers from Kavango West to search for more information about the cultural norms and songs that used to be performed as reiterated by Chikamori et al. (2019) in their study.

The Unongo Youth Cultural Group is always ready and prepared to fulfil community entertainment needs through traditional means. Moreover, the Unongo Youth Cultural Group concert during the circuit cultural festival is always a welcome social activity that attracts most of the villagers. The group has extraordinary skills in *drum making, drumming, music and dance*. As a result, many schools and individuals hire their drums and/or invite the group to their ceremonial events for entertainment purposes.

¹² Unongo Cultural Youth Group was established in 15 of March 2007 at Insu village. Board of directors: Mr. Kakoro Toivo (Chairperson), Mr. Situmbi Kleopas (Vice-chairperson), Ms. Hega Sofia (Treasurer), Ms. Sidonga Kerthu (Group secretary) and Mr. Maseka Mathias (Trainer and personnel advisor) during the time of the study.

Also, schools make use of the Unongo Youth Cultural Group to train learners during the circuit cultural festival. Further, this group plays a vital role in transferring drumming and dancing skills to both teachers and learners who partake in the annual school cultural festival. In this group, individual members consciously used their family’s clan name when participating as their pseudonyms (see Appendix R).

4.3.3.3 Teacher participants

In the study, six Grade 10 Physics teachers from three schools participated (two from each school). In addition, a female Physics teacher – also a BEd (Honours) student at Rhodes University during the time of the study, requested permission to participate in the study and I agreed. Most of these Grade 10 Physics teachers were from a rural community and were responsible for the cultural groups in their schools.

Table 4.1: Profile of the Grade 10 Physics teachers

Pseudonym	Age	Gender	Professional Qualification	Teaching experience in		School location
				Natural Sciences/Physical Science/Life Science, Physics, chemistry, and Biology	Grade	
Mburu	38	Male	Diploma	6	8-9	Rural
Lyako	41	Male	MEd (Psychology)	15	10-11	Rural
Nda-Kulanda	35	Male	BEd (Hons)	9	8-9	Rural
Kambinda	34	Male	Diploma	6	8-9	Semi-urban
Kondjereni	36	Male	Diploma (MASTEP)	8	8-9	Rural
Kaurungi	30	Female	BEd (Hons)	4	10-12	Urban

Neporo (NB: this participant only participated in the semi-structured interviews)	35	Male	BEd (Hons)	10	10-12	Urban
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They had all been teaching Physical science in that community for a minimum of three years respectively and so they knew the community well. Teachers’ participation contributed greatly to constructing ideas on how the integration of indigenous heritage when teaching the concept of sound through the professional community of learning when engaged with the Unongo Youth Cultural Group. In doing so, I also worked on my data-generating techniques which I turn to next.

4.4 Data Gathering Methods

In this study, I used multiple data gathering methods to answer my research questions, namely interviews (semi-structured and stimulated interviews), observations (participatory observations and videotaped lessons) and journal reflections. In light of this, Aguilar Solano (2020) suggests that using different data gathering methods helps with the triangulation of data. Concurring, Koo et al. (2020) maintain that these multiple methods might provide more holistic and comprehensive data. In addition, Cohen et al. (2018) point out that using a variety of data gathering methods allows for the gathering of rich data. The Grade 10 Physics teachers learnt the ways of integrating IK during the workshops and intervention.

I also positioned myself as a co-learner and provided regular feedback after each session – the Grade 10 Physics teachers were my co-researchers in this study since we all had to go into the community to find information on the cultural beliefs and technologies that would be relevant when teaching science. By doing so, it was hoped that they would be able to compare what they were taught at school and the knowledge acquired from the ECMs, to enable border crossing (Aikenhead & Jegede, 1999; Kwon, 2021).

To avoid the spread of the disease during workshops, the following guidelines were adhered to as prescribed by the World Health Organization (WHO) and the Ministry of Health and Social Services in Namibia:

- Wash your hands regularly with sufficient soap and running water; at least every house and the public area should have a hands-free sanitation bottle through the tippy tap project.
- Keep 70% alcohol-based sanitiser and sanitise every time.
- Clean and disinfect frequently touched objects.
- Wear masks.
- Do not touch your eyes, mouth, and nose with unclean hands.
- Keep a social distance at all times of 1.5 metres.
- Keep temperature records for participants (see Appendix R).

I now discuss each of these methods below.

4.4.1 Interviews

The interview method involves the presentation of oral-verbal stimuli and replies (Gill et al., 2008; Hadden, 2017). Leenders et al. (2019) argue that an interview is a two-way conversation in which the interviewer asks the participant questions to generate data and to learn about the ideas, beliefs, views, opinions and behaviours of the participants. To establish Grade 10 Physics teachers' experiences, pedagogical insights and attitudes toward the use of IK in science teaching and to enable us to answer research questions 1 and 2, I adapted the interview schedule from Cetin-Dindar and Geba (2017) (see Appendix I).

4.4.1.1 Semi-structured interviews

The semi-structured interview (SSI) is designed to establish subjective responses from persons regarding a particular situation or phenomenon they have experienced. McIntosh and Morse (2015) state that the SSI employs a relatively detailed interview schedule and may be used when there is sufficient objective knowledge about a phenomenon, but the subjective knowledge is lacking. The SSI is commonly used in research projects to corroborate data emerging from other data sources.

It seldom spans a long time and usually requires the participant to answer a set of predetermined questions while also allowing for probing and clarification of answers.

Brown and Danaher (2019) emphasise that SSIs define the line of inquiry. In the planned SSIs, I pursued lines of inquiry that directly related to the phenomenon being studied and explored and probed the participants – bearing in mind that it is easy to get side-tracked by trivial aspects not related to the study. Due to the COVID-19 pandemic, I used an average of 30 minutes for the telephone interview with Neporo, and the rest were conducted face to face. Social distancing and avoiding physical contact with the participants were adhered to throughout the interviews.

I repeatedly listened to the audio recordings to familiarise myself with the data. I transcribed all the videos and audios myself; hence, as in Khupe and Keane's (2017) description, I was a researcher-transcriber. I understood that in transcribing, I was re-presenting the events (the interviews) and that I would not be able to recreate the actual events (Tilley, 2020). Doing the transcriptions demanded a lot of time. I had more than six hours of video footage and almost three hours of interviews to convert to text. In the beginning, I needed about an hour to transcribe no more than five minutes of talk. However, doing the task myself kept me immersed in the context of the events. I thus began analysing the data during the transcription process (Jiang et al., 2021). The SSIs were conducted individually with the six Physics teachers from three schools in the Kandjimi Circuit and these were recorded with the permission of the participants. The SSIs provided the participants with the freedom to answer the open-ended questions using as much time as they wished; their responses were often not in-depth. Hence, in-depth, guided and SSIs are disparate interview types that must not be conflated.

4.4.1.2 Stimulated recall interviews

Skog et al. (2020) describe stimulated recall interviews as a research technique in psychology. It has also been used extensively in teaching and learning research, classically to explore teachers' intellectual processes while reflecting on their teaching following a teaching episode (Paskins et al., 2017). Though Bloom (1953) used audio recordings in his inventive study, video recordings are now commonly used in research (Nguyen & Tangen, 2017). Moreover, video-stimulated recall is a research technique in which participants view video recordings of themselves participating in

a particular event – in this case, it was lessons which took participants and researchers an average of 45 minutes each to watch the recorded videos. The videos acted as a prompt to help the individual participants recall their thoughts about their observed actions as much as possible as they occurred during the event observed (Theobald, 2012).

A stimulated recall interview through video-stimulated recall is a method that shows research participants a video of their behaviour to prompt and enhance their recall and interpretation after the event, for example, when they participated in the professional learning community (Paskins et al., 2017) (see Section 2.1.1). During the video-stimulated recall, ECMs were excited and reflective after seeing themselves appearing on screen. Researchers have recognised video-stimulated recall as a valuable technique for exploring teachers' perceptions and beliefs in decision-making, especially for capturing teachers' thoughts in the classroom (Nguyen & Tangen, 2017).

It was seen that a stimulated recall interview moves closer to accessing rich, privileged data by watching the videos together with the members of the PLC. In this regard, the activities of the ECMs were videotaped or recorded. The stimulated recall interview provides a contextual and interpretively valid scheme to access teachers' epistemologies that complements existing methods to facilitate learning. Although there are benefits to using video-stimulated recall as a research technique, there are some limitations that need to be considered. For instance, Gass and Mackey (2020) postulate that one cannot assume that research participants can clear their internal processes of an event as these behaviours are observed after they have participated in the activity.

4.4.2 Observations

Observation is a commonly used technique, particularly in educational studies. Scientifically, observation becomes a scientific skill requiring all senses. Marshall (2021) outlines observation as the regular description of events, behaviours and artefacts in the social setting chosen for study. Creswell et al. (2016) explain that 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 while interacting with learners.

4.4.2.1 Participatory observation

Participant observation is often described as offering a range of options from acting largely as an observer (outsider) to actively participating (insider). Therefore, if a researcher practices participant observation, they will join a group as a participating member to get a first-hand perspective of the group and their activities. Participating in the group gives the researcher the ability to experience events in the same way other group members experience them. Essentially, in every session, an average of 90 minutes was spent on participatory observations in which ECMs were performing activities of *drum making, drumming, music and dance* with the group giving the researcher greater empathy, as well as a much more in-depth understanding of the group members and their activities.

During the presentations by the ECMs, the Grade 10 Physics teachers and I were participant observers, consistent with the interpretivist and Ubuntu perspective where I could gather live data from a naturally occurring situation as highlighted by Bertram and Christiansen (2020). What I observed during the demonstrations, presentations and interaction is that the Grade 10 Physics teachers were very attentive and seemed to be enjoying the presentations during the participatory observations. As a result, they asked the ECMs some questions. Lastly, it seemed that these Grade 10 Physics teachers learnt something from the presentations, as I discovered that they were able to put into practice the knowledge gained from the presentations when they were co-developing exemplar lessons. Manolchev and Foley (2021) believe that the goal for the design of research using participant observation as a method is to develop a holistic understanding of the phenomena under study that is as objective and accurate as possible given the limitations of the method. I further suggest that participant observation was used as a way to increase the data validity.

In this study, participant observation was chosen as the process enabling the researchers to learn about the activities of the people under study in their natural setting through observing and participating in the activities of *drum making, drumming, music and dance*. It is affirmed that it provides the context for the development of sampling guidelines and interview guides (Manolchev and Foley, 2021). Through the engagement of participatory principles, the community partners and I designed this study to reflect a deep respect for the intellectual and natural capacities of the Ukwangali community. Full and active participation by ECMs in the development of the research

project, enrolment of participants and modification of the discussion guide as well as collection and analysis of data, ensured a participatory approach of mutual benefit.

4.4.2.2 Lesson observations

In this study, classroom observations were endorsed for understanding the on-going influential process of the intervention when Grade 10 Physics teachers participated in the professional learning community. During the lesson observations, with the permission of the Grade 10 Physics teachers who presented in class, all presentations were videotaped. By doing so, I was able to watch these videos repeatedly together with the Grade 10 Physics teachers to access in-depth data. That helped the Grade 10 Physics teachers to improve on ways to integrate IK into their science teaching in the following lessons and helped me to administer the stimulated recall interviews. Observation in research is a way of gathering data on individual behaviours, interactions or the physical setting by watching behaviour, events and artefacts (Eradze et al., 2017).

Classroom observation is also defined as a process in which the observer sits in on one or more classroom sessions, records the teacher's teaching practices and learner actions and then meets with the teacher to discuss the observations (Eradze et al., 2017). Therefore, it is a collaborative process for both participants and the researcher having significant roles before, during and after the observation process.

The study used classroom observations as a viable and effective mechanism for providing me with the information needed about the role of community members' explanations in the Physics teachers' classroom behaviour. In this study, with the permission of the participants, I observed and video recorded three Physics lessons from each participant (two Grade 10 Physics teachers) for an average of 40 minutes in three different schools. In total then, I observed six lessons from the three Grade 10 Physics teachers (two lessons for each participant). That provided adequate data to understand the participants' CK and PCK on the development of the concept of sound in Grade 10.

4.4.3 Reflective journals

The study aimed to ascertain how teachers mediate learning of sound in Grade 10 Physics using the indigenous technology of *drum making, drumming, music and dance* when teaching the topic of sound. The Grade 10 Physics teachers' reflective journals were intended to provide qualitative evidence of the stages in the development of teamwork among the Physics teachers themselves as well as with the Unongo Youth Cultural Group as the ECMs.

In addition, the reflective entries provided an opportunity for me to explore the complexity of teamwork, identify the stages of its development and analyse its significance for teacher growth through co-developed exemplar lessons during their participation in the PLC. It seems, through reflection, participants became aware of their thoughts, positions and feelings about learning and the learning community. Bashan and Holsblat (2017, p. 2) explain that reflective journals comprise an important part of documenting the practice of different professions, such as “nursing, and in fields such as musical education, business administration, psychology, and education”.

The use of reflective journals in research plays an important role which includes strengthening the relationship between the researcher and the participants and improving the learning of research participants and researcher as well as improving the learning processes (Bashan, et al., 2017). In the study, community members were allowed to develop their reflections verbally in the language of their choice, particularly the Rukwangali dialect, and this enabled research participants to work in harmony and built trust.

Table 4.2: Data gathering strategies at different stages

Phase	Methods used to gather data	Data to be gathered	Research question
1	Semi-structured interviews	Teachers' views on the use of indigenous technologies in science teaching.	1
2	Participatory observations, journals and stimulated recall interviews	Construction of musical instruments: Ngoma; Explanations and stories about the instruments of ngoma; Tanning skin for drumhead; and Drumming techniques.	2
3 & 4	Co-development of exemplar lessons, discussions and reflections	Cultural knowledge from the community members on <i>drum making, drumming, music and dance</i> .	3
5	Lesson observations, reflections and stimulated recall interviews	Integration of indigenous technologies in the exemplar lessons.	4
6	Sharing or talking circles	Validate data for research questions 1-4 while Grade 10 Physics teachers, ECM and researcher sit around the fire.	

Below I present the research process of the study.

4.5 Research Process

4.5.1 Phases of the research

The forms of data generated in this study included:

- Field notes (in observations workshop two). I inscribed notes from my observations, through both formal and informal conversations. The informal discussions were not so much for building up the findings, but they immensely contributed to my understanding of the context and to the data gathering techniques following my research process which consisted of six phases.
- Audio records of interviews during the semi-structured interviews.
- Video-stimulated recall.
- Completed lesson plans, syllabi, schemes of work, and examiners' reports.
- Teachers' reflections.

Phase: 1

The semi-structured interviews were used in this phase. This baseline data enabled me to answer my research question 1.

Workshop 1:

The orientation workshop was to familiarise the participants with the study and share how Grade 10 Physics teachers teach the topic of sound in their classrooms. In addition, the participants received the transcription of the semi-structured interviews for member checking which consisted of two workshops.

Workshop 3: In this workshop, participants were able to validate the transcript data generated during workshops 1-2 through member checking.

Phase: 2

The study had a minimum of four visits to the site (Unongo Youth Cultural Group) in the community since they were the custodians of the cultural heritage of *drum making, drumming, music* and *dance*. At this phase, data were generated using participatory observation, videotaped lessons and reflections to answer research question 2.

Visit 1: To know each other, the Grade 10 Physics teachers were able to familiarise themselves with the site and community members, agree on the next visit date and build mutual trust between myself and the participants.

Visit 2-3: Grade 10 Physics teachers engaged with the Unongo Youth Cultural Group in all the processes of *drum making* and this allowed us to observe science embedded in the entire indigenous practice of making drums.

Visit 4: Community members were allowed to demonstrate and explain *drumming, music* and *dance* to the participants. During this visit, data were gathered through participant observation, thereafter, they were validated by stimulated recall interviews. Participants were allowed to reflect to develop their field notes about science lessons and *drum making, drumming, music* and *dance*.

Phase: 3

After having completed the site visit, the group reflected on the demonstrations and explanations received from the ECMs. During this phase, the lecturer who was my critical friend facilitated the ways of integrating IK into science lessons.

Phase: 4

Workshop discussions and reflections were used for gathering data to answer research question 3. Observation (videotaped lessons) and stimulated recall interviews were used to answer research question 4 using the TSPCK components for the transformation of knowledge (adapted from Mavhunga et al., 2016, pp. 312-313).

Phase: 5

The Grade 10 Physics teachers mediated learning of the exemplar lessons focusing on the science concepts and using the exemplar lessons as the vehicle for identifying indigenous technologies which were suitable for integration. I used lesson observations to generate data, in which three Grade 10 Physics teachers were observed when mediating exemplar lessons.

Phase: 6

In this phase, after nine months of data collection, I initiated a round-off visit in which Grade 10 Physics teachers, ECMs and I validated data through sharing or talking circles as postulated by Chilisa (2012) and Lavallée (2009). This validation of data was motivated by telling stories while sitting around the fire. I now discuss how I negotiated access in this study.

4.5.2 Negotiating access

Before asking the Grade 10 Physics teachers to sign the consent forms, I met them as they came for their first subject meeting in 2019 at the circuit and negotiated with them verbally to be part of my research. I explained to them the following aspects:

- The nature and the purpose of the study.
- The number and nature of workshops, observations, and stimulated recall interviews to be conducted.
- I also explained the mutual benefits for them should they be involved in this study and negotiated and sought permission from the local community members who were experts in IK (*drum making, drumming, music and dance*).
- I asked permission from all participants (teachers and community members) for videos to be taken. However, if they were not happy with the videotaping of the demonstration lessons and workshops, I took field notes.

Fundamentally, such discussions enabled me to clarify issues and dispel fears so that the participants would be in a position to make informed decisions without feeling coerced to take part in the study. I assumed that where there is clarity and a relationship based on mutual trust, participants could exercise their freedom of choice.

None of my visits was made without the agreement of the participants since I did not want to be seen to be intruding. I called the principal, the teachers and the secretary of the Unongo Youth Cultural Group before each visit. Carefully negotiating one's way into the participating community is a sign of respect for the participants' traditional and social structures. Khupe (2014) cautions that rural communities are structured differently from non-rural ones. That is, certain hierarchies exist in rural communities that do not exist in urban and other non-rural areas.

4.5.3 COVID-19 preventative measures during workshops

The term COVID-19 (Corona) is the disease that started in Wuhan a city in China in December 2019. This disease is caused by SARS-CoV-2 which was discovered in 2019. Namibia is one of the countries where new COVID-19 cases were increasing daily when this study was conducted. In this regard, before every session began, I always discussed the related protocols and the community responsibility such as:

- The serious nature of COVID-19.
- The importance of each individual's knowledge of the risks of the virus.
- They need to monitor their health.
- The need to notify appropriate personnel if they were symptomatic and/or exposed and to be tested if necessary.

Therefore, everyone had a personal responsibility to practice social distancing, frequent hand washing, cough/sneeze protocol, proper wearing of face masks, avoidance of touching their face and respecting others. Grade 10 Physics teachers and I were able to mobilise the ECMs to have tippy taps¹³ erected at every entrance of their homesteads and public areas like churches and traditional courts to ensure regular hand washing. In addition, tippy taps were the motivation for people to prioritise hand washing as shown in Figure 4.5.

¹³ Tippy taps are locally made devices for washing hands with running water. They are simple and low-cost, enabling technology that provides adequate water sources and hand washing stations.



Figure 4.5: A tippy tap mounted at the public area of Nkurenkuru veterinary rural extension

One of the common symptoms of COVID-19 is fever, causing the body to have a high body temperature. The other symptoms of COVID-19 apart from high fever are dry cough, tiredness, severe headache, diarrhoea, body aches, difficulty in breathing and a tight chest. All the symptoms were explained to the participants before our workshops. The only error made was that I did not write these symptoms in the vernacular language – *Rukwangali* – although I did translate them orally. Temperatures were measured in degrees Celsius ($^{\circ}\text{C}$) as a recommended unit in Southern Africa as shown in Appendix R.

4.6 Validity and Trustworthiness

According to Humphreys et al. (2021), validity measures how accurately a study or research instrument measures what it intends to measure. Broadly speaking, validity is “the quality of being logically or factually sound; soundness or cogency” (Humphreys et al., p. 2). However, in qualitative research, validity is about trustworthiness which may be addressed through being honest and transparent, through the depth, richness and scope of data gathered, the participants

approached and the extent of triangulation (Cohen et al., 2018). Triangulation of data and member checking are some of the ways to ensure that the data is valid and trustworthy as reiterated by Aguilar Solano (2020).

In this study, enhancing the trustworthiness was achieved through the triangulation of qualitative methods. There were longstanding and vibrant discussions within the study regarding the value of triangulation. To ensure validity and trustworthiness in this study, I used a variety of data gathering techniques for triangulation purposes, extending from Coyne (2016) who postulates that the value of research is strengthened by its trustworthiness. In addition, the interview transcripts were sent back to participants for member checking. That validated the interview data through consultations with the participants (McIntosh & Morse, 2015).

In doing so, I chose the method of inquiry of gathering stories through sharing or talking circles (Chilisa, 2012; Lavallée, 2009). Sharing circles were used to capture participants' experiences related to the information provided for this study. The sharing circles are equivalent to focus groups in qualitative research where the researcher gathers information on a particular topic through group discussions and reaffirms that specific discussion. Connelly (2016, p. 435) argues that trustworthiness is "a degree of confidence in data interpretation and methods used to ensure the quality of research". Furthermore, the researcher is required to use the four indicators of trustworthiness which are credibility, dependability, conformability and transferability to help strengthen my study. All these indicators have added value to my research product. Kyngäs et al. (2020) briefly discuss what each of these means: "Credibility is concerned with whether or not the research findings represent a credible, conceptual interpretation of the original data". "Dependability is concerned with consistency across the research starting point, data collection, and analysis. ... Conformability is a measure of how well the study findings are supported by the collected data" and "authenticity describes the extent to which researchers fairly and faithfully show a range of realities" (pp. 43-46).

Equally, in every study, the researcher is apprehensive about the connection between the data and the result as well as if the research has sufficient authenticity demonstrating the alignment between the result and data. In addition, Connelly (2016) accentuates that the indicators help make the findings applicable in other contexts. Taking advice from McIntosh and Morse (2015), data were

validated with the ECMs and Grade 10 Physics teachers while sitting around the fire (see Figure 4.6 below). That is, we shared the findings verbally with them and reflected on what emerged during the demonstrations and explanations of *drum making, drumming, music and dance*.



Figure 4.6: Data validation through talking circles (Chilisa, 2012)

Moreover, stories were told in the mother tongue of *Rukwangali and Runyemba* to pass the knowledge and wisdom of elders to young people (Lavallée, 2009). For instance, the Grade 10 Physics teachers and I sat around the fire while the ECMs told us stories. Below is an example of a story that was told.

For instance, a story about a couple:

There was a wedding in the community. The groom and bride have only invited one member per family to attend the wedding party. The disagreement begins in one family over who would stay and who would go to attend the wedding ceremony. The wife decides to take her husband to their natural family's lawyer, to decide who should go and who should remain. The couple went to the riverbank who was their family's lawyer over the case between the couple. The wife told the husband to ask the lawyer first.

Husband: "Should I go to the wedding party or remain home"?"

Lawyer: “Remain home”!

Wife: “Should I remain home or go to the wedding party”?

Lawyer: “Goo to the wedding part”!

The wife certainly asks the husband, who will go to the party? The husband shouted, “you won and go”!

In this manner, the Physics teachers were allowed to integrate their own stories into science education as reiterated by Collins (2021). Equally, the story teaches about harmony in the community which describes the realm of the dialectical relationship that occurs between cultural traditions and the existence of social space in society (Nurhakki et al., 2021). Elders teach their children through stories, songs and dance. These are their ways of passing knowledge and wisdom that honour and value nature. Similarly, the story also reminded the Grade 10 Physics teachers about the mediation of the topic of echoes – *the reflection* of sound. It was said, “Each of the couples heard his or her reflected sound by the riverbank”. These Grade 10 Physics teachers used this story to teach the concept of sound on the topic of echoes as reflected in Mburu’s lesson (see Section 8.4.3; Figure 8.11–8.12).

4.7 Ethical Considerations

Researchers working with human subjects ought to be guided by ethical principles of respect for persons, non-maleficence and beneficence. As such, facilitating free and informed consent is a key ethical standard to consider when conducting social research. The principle of informed consent is formalised to help create research relationships that are founded on ‘trust and integrity’ (Klykken, 2021). According to Cohen et al. (2018), informed consent involves the signing of a participation contract. Similarly, Bertram and Christiansen (2020) emphasise that consent means an agreement reached after a discussion between the researcher and the research participants. In this study, informed consent forms were signed by both Grade10 Physics teachers and the Unongo Youth Cultural Group who were aged 18 and older before the data gathering process took place. In this study, I used the PAR approach that centred on people in relationships with each other and with

the research topic (Khupe, 2014). Admission¹⁴ to a community is a privilege rather than a right (Cohen et al., 2018).

The study involved conducting workshops, participatory observations and interviews with academic and non-academic participants. The ethical issues emerging from the study related to consent, data ownership and the management of confidentiality and anonymity. As a member of a professional community, I strove to meet the needs of research participants and the greater society of the Unongo Youth Cultural Group. My ethical conduct has worked across cultures in lengthening the period of being part of the research. Issues such as exploitation, community damage and inaccurate findings were seriously avoided.

4.8 Chapter Summary

In this chapter, I presented the research methodology underpinning this study. Within the research methodology, I presented the research paradigms informing this study, namely the interpretivist and indigenous research paradigms. Moreover, I discussed the research design employed in this study, that is, the qualitative case study. The research site and selection of participants were explained and data gathering methods were followed by ethical considerations. It ended with a chapter summary. In the next chapter, I present and discuss the findings from this study.

¹⁴ I use the term admission to refer to the access to the participants such as grade 10 physics teachers and community members.

CHAPTER FIVE: SEMI-STRUCTURED INTERVIEWS

In qualitative research, the researcher aims to understand people's lives. Interviews generate deeply contextual accounts of participants' experiences and their interpretation of them. The interaction that takes place during interviews between researchers and participants may be beneficial for the participants and provide them with the opportunity to explore events in their lives. (Doody & Noonan, 2013, p. 2)

5.1 Introduction

To understand the participants' contexts, views and perspectives, semi-structured interviews were used in the first phase of this study. As indicated in the epigraph, the interactions that take place during interviews are beneficial for participants and also provide them with an opportunity to explore events (Doody & Noonan, 2013). Hence, in this chapter, I present, analyse, interpret and discuss data from semi-structured interviews conducted with the six participants involved in the study.

The main purpose of this phase and the semi-structured interviews were to establish the teachers' experiences, pedagogical insights and attitudes towards the use of IK in science teaching. The data sets generated were intended to address my research question 1:

What are Grade 10 Physics teachers' experiences, pedagogical insights, and attitudes toward the use of IK in science teaching?

Based on the thematic analysis (Truong et al., 2022), six sub-themes, four themes and seven categories were generated. Key items of data from the semi-structured interviews were recorded in a form that was developed based on the interviews' schedule guided by research question one. A manual colour coding method was employed to highlight common and different concepts and thereby generate initial codes. For instance, data sets related to the understanding of the integration of IK were coloured in green, challenges regarding IK integration were coloured in yellow, the

data related to practical activities were highlighted with dark yellow and finally, cultural heritage was coloured in dark red (see Appendix BB).

Codes from all excerpts were collated to generate sub-themes and main themes. Essentially, coding means highlighting sections of a text, usually phrases or sentences, and coming up with shorthand labels to describe their content.

The analysis of qualitative data revealed different perspectives of Grade 10 Physics teachers towards the use of IK in science teaching and the responses were classified into four broad themes. The first theme was based on participants' existing knowledge and perception of the use of IK in science teaching. The second theme pertained to teachers' understanding of the curriculum and IK integration into the teaching of science. The third theme revealed teaching science using cultural artefacts such as traditional threshing, etc. The fourth theme demonstrated teachers' understanding of hands-on practical activities in science teaching.

5.2 Development of Themes for this Research Question

The main goal of this study was to mobilise the indigenous technology of *drum making, drumming, music* and *dance* for cultural revitalisation and indigenisation of the science curriculum. I developed both interview schedules using the research goal, literature and theory in this study. In so doing, I used various codes for data and the participants. For instance, I used the following codes: SSI. Likewise, for each theme, the data from both tools were combined and coded according to the similarities and differences in opinions and answers. This assisted me to understand the similarities and differences of ideas among participants.

Solkin (2022) and Boyatzis (1998) described the thematic analysis as a method for identifying, analysing and reporting patterns (themes) within data. In this study, therefore, a thematic analysis was done using guidelines outlined by Braun and Clarke (2019). In so doing, they organised and described my data set in (rich) detail as shown in Figure 5.1.

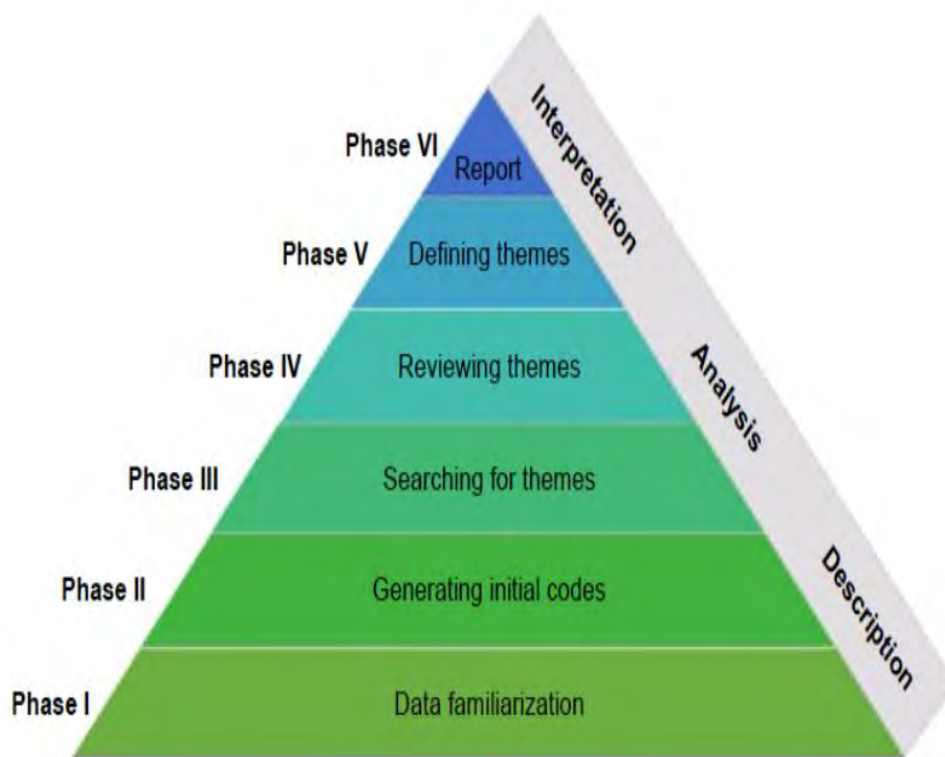


Figure 5.1: Steps followed for qualitative analysis of data involving seven Grade 10 Physics teachers in semi-structured interviews (adopted from Nandini et al., 2022, p. 149)

Data were analysed by following the six steps explicated below. The integration of IK remained the top catalyst in the Africanisation of the curriculum.

Phase I: I familiarised myself with the data. The iterative process of reading and re-reading verbatim transcriptions provided identification of the patterns engrossed in data. Equally, familiarisation entailed knowing my data which involved transcribing audio recordings and reading through initial notes (Cohen et al., 2018).

Phase II: I generated initial colour codes for main themes and sub-themes. After familiarisation with data, initial codes were generated as per Grade 10 Physics teachers' responses. It was a very important phase where I ensured that all actual data extracts were coded and then collated within each code. In this regard, Cohen

et al. (2018) emphasise that it is important to look over the codes and create and identify patterns among them, and start coming up with themes.

Phase III: I searched for themes for categorising the data.

Phase IV: I reviewed the themes. For the improvement of generated themes, a review process was done and it involved the process of merging different categories into new categories.

Phase V: I defined and named themes. The emerging new themes were defined and named. This phase allowed scope for a detailed description of the data.

Phase VI: I produced the report. The report was built based on the contents of the emerged themes (see Tables 5.1 & 5.2).

Table 5.1: Themes emerging from semi-structured interviews

<i>Research Question: What are Grade 10 Physics teachers' experiences, pedagogical insights, and attitudes toward the use of IK in a science lesson?</i>		
Themes	Theory	
	Literature	Theoretical Framework
Teachers' knowledge and perception of the use of IK in science teaching.	Reddy (2019). Ogunniyi (2007a, 2004, 1997, 1988).	<u>Accommodation</u> refers to how people adapt their ways of thinking to new experiences. Preferably, when their IK clashes with the IK of other <u>cultures</u> . Similarly, when two cultures or systems of thought meet, co-existence can only be found through conceptual <u>appropriation, accommodation, integrative reconciliation and adaptability</u> .
Teachers' understanding of Curriculum and Indigenous Knowledge.	Le Grange (2019)	Call for a <u>decolonised curriculum</u> . Current textbooks make exclusive reference to <u>African IK</u> .

	Ogunniyi (2007a)	A Science-IKS curriculum that reflects useable images of both systems of thought provides indigenous and non-indigenous learners access to different means of knowing and interpreting experience.
Teaching science by using cultural artefacts.	Bhabha (1994); Karlsson et al. (2020).	<p>The adapting of a curriculum so that it meets the cultural needs of the learners is known as <u>cultural translation</u> (Mukwambo, 2017).</p> <p><u>The capability of translating and transforming scientific content from one national language into another and between everyday and academic discourse.</u></p> <p>When two cultures or systems of thought meet, co-existence can only be found through conceptual appropriation, accommodation, integrative reconciliation and adaptability (Ogunniyi, 2004).</p>
Practical activities in science lessons.	Harman et al. (2016)	Learners learn <u>through hands-on activities</u> (Abdussuykur et al. (2021), <u>living, and gaining first-hand concrete experiences.</u> Moreover, to provide support to teachers.

After the extraction, separation, grouping and abstraction of transcript findings, I organised the findings into themes- sub-themes and categories.

Table 5.2: Theme, sub-themes and categories grounded in data from semi-structured interviews from six Grade 10 Physics teachers

The theme I: Teachers' knowledge and perception towards the use of IK in science teaching.
Sub-theme 1: Attitude towards integration of IK
Sub-theme 2: Importance of integrating IK
Theme II: Teachers' understanding of curriculum and indigenous knowledge integration.
Sub-theme 3: Behavioural factors
Category 1: Lack of training and experience
Category 2: Fear and inferior
Sub-theme 4: Folklores
Category 3: Family
Category 4: Orally
Theme III: Teaching science by using cultural artefacts.
Sub-theme 5: Cultural heritage
Category 5: Help from outside school
Theme IV: Practical activities in science lessons
Sub-theme 6: Hands-on activities
Category 6: Visualisation

I now discuss each of these themes below.

5.2.1 Teachers' views on the use of indigenous knowledge in science teaching

The detailed findings from the SSIs are shown in Appendix L. It emerged that the participants had some common and different viewpoints about the use of indigenous technologies or indigenous practices in science teaching, particularly when teaching Grade 10 Physics concepts. For instance, when asked about the views on the integration of IK into the teaching of science, the six Physics teachers involved in this study, namely Mburu¹⁵, Lyako¹⁶, Nda-Kulanda¹⁷, Kambinda¹⁸, Kondjereni¹⁹, Kaurungi²⁰, and Neporo²¹, explained the use of IK in the science curriculum. In addition, they emphasised the significant role played by IK in teaching. For instance, Mburu stated that: *“It is difficult to say because once you use the word ‘IK’ I thought of the investigating knowledge in science classroom”*.

Moreover, when Nda-Kulanda was asked about the use of IK in science lessons, he revealed that he relates the phenomena of echoes with the learning involving laboratory activities. This finding coheres with Aikenhead and Jegede (1999) postulate that learners struggle with border crossing from home to school. On the other hand, Nda-Kulanda's view is that Physics mostly has to do with energy and matter, for instance, water waves, teaching the concept of the wave and teaching-learning from the textbook which is a secondary source. It is better to teach learners from the primary source, for instance, by throwing a wooden block in the water so that they can comprehend why it floats.

¹⁵ Tireless and fearless like the Honey badge

¹⁶ Have a taste

¹⁷ The firstborn in the family is a boy, in this case, it is the firstborn of Kulanda

¹⁸ The second born in the family and is a boy

¹⁹ Try harder

²⁰ Settler

²¹ A caregiver

According to Neporo, IK seems to help learners to learn through life experience. He further expressed that:

When a teacher links the content in class with the real-life application outside it makes it learning more meaningful. Equally, in examination questions like how sound is produced, then learners remember oh the other day we had the cultural group beating drum and then the sound was produced. Now learners can relate to what they have experienced physically to what they have been asked.

From this excerpt, it could be deduced that Neporo seems to have some understanding that bringing an outside environment into the classroom or taking learners to the outside environment has the potential to enrich learning (Kibirige & van Rooyen, 2006). The excerpt above resonates well with Seehawer (2018) who stated that using IK as a tool can make WS more accessible, moving from the familiar to the unfamiliar. In addition, integrating IK into the teaching builds a bridge between classroom science and home knowledge and brings back the role of the community and elderly people (since they are the custodians of the IK) in the education of their children. It could be surmised that Neporo seems to support the integration of IK which he views as an enabler of learning. This finding tends to corroborate with Seehawer and Breidlid (2021) who accentuate that there should be a dialogue between IK and WS.

According to Mburu, if teachers recognise learners' IK when teaching, that will enhance their understanding even if the topic was too abstract. In this regard, Mburu points out that integrating IK carries more advantages than disadvantages. Notwithstanding, the main challenge though might be the learners' cultural backgrounds and how they perceive things. That is, their cultural backgrounds might be different from others. According to Mburu, if taught effectively, IK integration develops learners' thinking and knowledge. However, if not handled effectively, some learners might misinterpret it and confuse it with the theory that they learnt in the classroom. For instance, Kambinda indicated that his learners could not agree that the rainbow is not an animal but a mixture of different colours. It could be argued, therefore, that Kambina's learners' cultural beliefs were dominant (Ogunniyi, 2007a). These findings have implications for how the curriculum is organised.

In this regard, Neporo indicated that the curriculum seems to oblige teachers to put WS ahead of local knowledge. He thus suggested that science teachers should make legitimise IK in the curriculum. Kaurungia added that the related cultural music instrument is never mentioned in any past examination paper because WS is considered accepted globally.

These teachers seemed to be mindful of the dominance of the scientific worldview (Ogunniyi, 2007a) and were in favour of the recognition of IK in the curriculum. For instance, Neporo commented that “*science is everything we do, no matter what*”. Concurring, Kaurungi reflected that “*science is the matter of which everything is composed*”. To Mburu, “*everything originates from science*”. Finally, Nda-Kulanda elaborated that “*there is science in everything, life is science and science is everywhere even in culture*”.

In the above excerpts, it could be deduced that these teachers seemed to be aware that learners can learn science from their immediate environments. These findings seem to be congruent with Önal and Çevik (2022) who postulated that outdoor learning activities are crucial as far as the discovery of nature, social experiences and concrete living experiences for learners. That is, learning does not exclusively take place in the classroom setting instead, it also takes place where social life takes place such as playing grounds and civil society organisations like Unongo Cultural Youth Group in the context of this study.

5.2.2 Teachers’ understanding of curriculum and indigenous knowledge

Kaurungi seemed to embrace the integration of IK in science teaching highlighting that it enables meaningful learning to take place. That is, IK can enable learners to understand science. Moreover, Kaurungi and Mburu indicated that “*We see how indigenous knowledge uses science and it helps us understand the science today*”. To Kambinda, “*There is science in cultural music, and studying sound using musical instruments makes it more interesting to teach about sound waves*”. Lyako added that “*sound is science and all sound, no matter what sound it makes, has scientific principles*”. Lastly, Kondjereni explained: “*There are a lot of things that the present science does not know about and every day we discover new*”. By inference, it can be deduced that these teachers view the integration of IK as something that can enable learners to learn science in their immediate environment (Futia & Vetrò, 2020; Seehawer & Breidlid, 2021).

According to Lyako, however, the science textbooks used in schools sometimes do not give examples of IK that can be integrated into teaching. Thus, textbooks or other curriculum materials should be designed in such a way that the teaching environment should revive the valuable cultural elements. These might appear as models, icons/symbols, vocabulary, patterns, case studies, analogies and practical activities with the connotation of IK (Mukwambo, 2017). In agreement, Neporo also explained the approaches used during his lessons:

I have been teaching Physical science for the past 10 years. I enjoy teaching science subjects. Back in high school, I was good at science subjects. There are numerous challenges when teaching science, indigenous knowledge remains outside the official school curriculum.

It could be hypothesised from this excerpt that similar to Lyako, this teacher feels that IK is not documented or included in the official curriculum. The argument is that the curriculum is silent about IK and uses the international standard as a benchmark for validation. Contrary to the assertion made by the teachers that IK is not included in the intended curriculum, a closer look at the syllabus shows the following:

The learning content in the syllabus is based on the Namibian context, although the themes and topics are on a variety of scales to meet international standards. Teachers are therefore urged, where appropriate, to use local examples to illustrate scientific issues, concepts, and processes (MoE, 2010, p. 2).

In the above-mentioned case, the curriculum is only used to advance the learning of science and seems not to promote and use cultural knowledge. Similarly, Lyako emphasised that it is not only the teachers who have a significant role in the use and modification of textbooks. Thus, in light of the above evidence, it could be argued that many teachers support the integration of IK for the reason of laying a learning foundation. Such a finding resonates with Mavuru and Ramnarain (2017) who explain that teachers should use their knowledge about learners' socio-cultural backgrounds and beliefs to create learning opportunities that harmonise the conflict between learners' background and science (Ogunniyi, 2007a).

The teachers involved in this study highlighted lack of training and experience as well as fear and inferiority, as being the common behaviours inhibiting them from integrating IK into science teaching. Based on the participants' responses, the following categories explicate particular behaviours.

Lack of training and experience: Irrespective of teaching experience and professional qualification status of the participants, lack of knowledge and skill in the integration of IK was found to be the most frequently mentioned among all Grade 10 Physics teachers during the SSIs. It could be argued that the curriculum of HEIs needs to be decolonised (Mutanho, 2021; Seehawer et al., 2022). Perhaps scholars cannot change the education system from the top, instead, they can initiate a decolonisation from the bottom up. For example, science teachers can integrate IK into their teachings, stimulate colleagues to do so too and raise interest among learners.

Fear and inferiority: Teachers have no confidence in integrating IK into their teachings. Hence, Neporo explicates that the curriculum is “*obliging teachers to put Western Science above our local science*”. Moreover, he commented that:

IK is not legitimate even if teachers attempt to integrate this knowledge into science teaching, assessment is established on Western Science. Almost 90% of the end term tests are from modern science. Learners doubted why they should learn IK while learners are officially going to be assessed in Western Science.

This excerpt seems to resonate with Ayeni and Aborisade (2022) who argue that the Western knowledge system is regarded as universal because Western education is embedded in many world cultures. The second sub-theme of curriculum and IK is folklore.

Folklores: Participants reported that IK is essential and is the traditional beliefs, customs and stories of a certain community. Hence, learners would learn concepts through storytelling. Mburu explained that it is “*best if concepts are elaborated well through stories*” as reiterated in Chilisa (2012). Equally, Neporo elaborated that “*culturally, IK should be preserving the cultural heritage of individuals, so that they do not forget their background as they learn through their beliefs and norms when elders tell those stories*”.

These excerpts seem to resonate with Ayeni and Aborisade (2022) who claim that IK is a knowledge system that is preserved within the boundaries of people's culture and exercised with skill, wisdom, conservation and environmental harmony as its trademark. It could be argued that IK is orally transferred from one generation to another (Kibirige & van Rooyen, 2006).

5.2.3 Teaching science by using cultural artefacts

The third theme is related to the participants' responses to integrating IK into the learning of Physics. Essentially, it emerged from the ways Grade 10 Physics teachers respond to and express themselves by using cultural artefacts in their science teachings. These Grade 10 Physics teachers revealed that cultural artefacts can be used to mediate the teaching and learning of Physics concepts in a science classroom. In this regard, Kaurungi emphasised that:

Let us say, you are a teaching mechanics. I normally talk about, because most of my learners come from inland (villages) where there is a very rare amount of water, people have to dig water from the ground, so, they normally use a bucket tied on two poles on with rope and lower it in a deep hole for collecting water. So, it is like a pulling system that makes work easier. They do that at home and it is not strange (SSI).

The excerpt contends that the NCBE (MEAC, 2016) mandates that a culturally responsive pedagogy be used to teach indigenous learners to assist them in learning science concepts. Hence, the choice of the pulley system, which is a cultural artefact found in learners' lived world creates an enabling context accessible to learners (Asheela et al., 2021). Kaurungi further referred to activities in her Physics classroom with her learners (Fakoyede & Otulaja, 2020).

Cultural heritage: This referred to the practice of fetching water when teaching the concept of mechanics – the pulley system – and Neporo mentioned the sound production in which a science teacher would use a guitar or drum- *ngoma* for learners to perceive sound via particle vibrations. Some Physics teachers, like Lyako and Kondjereni, supported the integration of cultural practices in science education because they thought that science was universal and that the integration would benefit IK. What is evident is that these teachers tended to view science as something that is practiced not only by the Westerners but by people all over the world. This resonates well with drumming, music and dance when teaching the Physics concept of sound (Liveve, 2017).

Help from outside school: Community members are the custodians of such cultural heritage from outside school. In this regard, Kambinda explained that:

The knowledge learners had at home and that of a learner learnt from school is prevalent over the knowledge from home. IK might help learners to come up with something that can sustain their life such as farming.

This excerpt seems to resonate with Twiselton and Truby (2020) who claim that schools can create the optimal culture and conditions for assisting professional development in partnership with outside the knowledgeable organisations.

5.2.4 Hands-on practical activities in science lessons

The fourth theme is based on participants' responses to how they teach Physics. The findings revealed that the Grade 10 Physics teachers involved in this study seemed to have some ideas on the use of hands-on practical activities. For instance, they commented that *visualisation* plays a major role during practical activities and enhances *collaboration* among science learners. In this theme, visualisation was identified as being the sub-theme in relation to hands-on practical activities in science lessons.

It should be noted that there may be other sources of perceptual richness, such as complex interactions between the represented elements that can be found in dynamic visualisations and animations. These teachers thus indicated that a hands-on practical activity carried out by the learners themselves is an essential element of good science teaching. For instance, Kambinda responded that hands-on practical activities emphasise the acquisition of practical skills in Biology, Physics and Chemistry. During exams, the practical paper is based on the content of the particular science subject. In addition, Mburu pointed out that:

Science practical activities may therefore involve illustrations of a phenomenon, providing experiences or getting a feel for the phenomenon by learners, exercises or routines for learners to follow, developing a particular skill, or becoming used to a piece of equipment or instrument.

It could be argued that such a teaching approach, which focuses on hands-on skills, can facilitate learners' understanding of how science works because science learners often follow instructions thoughtlessly without reflecting on the purpose of the practical. The excerpt above corroborates

with Ioannidou et al. (2022) who reiterate that the practical activities enhance the link between observations and conceptual ideas in which understanding of scientific methods and practices is promoted.

Nda-Kulanda explained how he values the hands-on practical activities when teaching his learners:

Drawing from practical work and/or activities is the key; sometimes I use the outside classroom to explore and engage learners when carrying out investigating activities. I use models, pictures and others to strengthen my teaching.

This excerpt seems to be congruent with Abdussyukur et al.'s (2021) assertion that a comprehensive module needs to be developed with real-life practical learning activities and experiments, authentic assessment, integration of media in lessons and innovative teaching strategies approaches. Similarly, the Namibian Senior Secondary Certificate for Ordinary Level Biology Syllabus (MoE, 2009, p. 27), states that “learners should get practical (experimental and investigative) skills and abilities that will allow them to be able to follow a sequence of instructions; use appropriate techniques; handle apparatus/materials competently; and have due regard for safety.” Practical work promotes scientific literacy for a scientific career and the development of scientific thinking and experimentation among science learners.

In addition, Mashoko (2022) emphasises the importance of the promotion of hands-on and minds-on approaches to teaching and learning in schools through the integration of IK artefacts. He further contends that the curricula approach underscores two critical issues: 1) science teaching should be associated with the lives of the learners, and 2) a localised curriculum should attempt to bring local knowledge into schools so that it can be recognised and be given respect by learners as they make associations with their cultural values with schooling. Woodley (2009) emphasis that if practical activities are planned and well-organised, the outcomes can be very rewarding in terms of meaningful learning. Practical work helps learners to find facts and arrive at new principles. It helps to develop creative thinking and verify facts and principles that are already taught (Nhase, 2019).

5.3 Challenges in Integrating IK with School Knowledge

The study showed that the Grade 10 Physics teachers seemed to have ideas on the use of hands-on practical activities that are in the form of IK in particular, as evidenced in Seehaver's (2018) study conducted in South Africa. During the interviews, for instance, they were able to mention some indigenous practices that could be integrated into their teaching. However, this study revealed that they seemed to have challenges that hinder the integration of IK into science teaching. For instance, IK is perceived as inferior knowledge and technology, urbanisation and industrialisation have suppressed IK (Aikenhead & Ogawa, 2007; Barua, 2010; Dick et al., 2022). In urban areas, the young men no longer sit with the elders to learn about life and how to live harmoniously with the environment and this has led to parts of IKS disappearing.

The Namibian NCBE (MEAC, 2016) encourages science teachers to use different knowledge sources. Yet, as alluded to above, the science textbooks used in schools do not give examples that reflect IK. So, an intervention like this has the potential to equip Physics teachers with skills and knowledge regarding the integration of IK into their teaching since they act as intermediaries, and negotiate between school knowledge and home knowledge.

5.4 Chapter Summary

The data presented in this chapter was meant to answer the research question: *What are Grade 10 Physics teachers' experiences, pedagogical insights and attitudes toward the use of IK in science teaching?* The following emerged from the data: teachers' knowledge and perceptions of the use of IK in science teaching and teachers' understanding of curriculum and IK to teach science using cultural artefacts and hands-on practical activities in science classrooms. The teaching approaches developed need to be related to real-life practices.

CHAPTER SIX: PARTICIPATORY OBSERVATION AND STIMULATED RECALL INTERVIEWS

Participant observation allows the researcher to study people in their native environment, thereby offering the opportunity to understand things from the perspective of the people being studied. (Takyi, 2015, p. 865)

6.1 Introduction

While science is a school subject that can be accessed through textbooks, IK is not documented. Instead, it exists in the heads of the ECMs or elders who are the custodians of such knowledge or cultural heritage. As a result, teachers cannot access such knowledge unless they find ways of engaging in community coffers of knowledge (Mutanho, 2021) as highlighted in the epigraph above. It is for this reason that I negotiated with the ECMs such as the Unongo Youth Cultural Group for them to conduct practical demonstrations and explanations for us on *drum making, drumming, music and dance*. I did this because I wanted to understand the learning opportunities created (or not) by such practical demonstrations and explanations, thereby answering the second question of my study through participatory observation which is:

How do the Grade 10 Physics teachers interact, participate and learn (or not) during the ECMs' practical demonstrations and explanations on drum making, drumming, music and dance?

Following the cultural practices of the Ukwangali, Grade 10 Physics teachers and I were welcomed by ECMs with songs and dance as shown in Figure 6.16. In my view, there is huge potential for researchers and IK holders to co-produce knowledge that would be best placed to drive the science curriculum. In this chapter, I thus present, analyse, interpret and discuss data generated through participatory observation, stimulated recall interviews as well as teachers' reflections. In this chapter, I use the word *Otate* when referring to father and *Onane* when referring to mother to show respect and honour to the elderly.

6.2 Knowledge in Ukwangali

The data sets from the ECMs during *drum making, drumming, music* and *dance* are primarily presented in three forms of knowledge that emerged from this study.

- Language;
- Cultural technologies; and
- Practical skills.

However, numerous forms of knowledge surfaced during this study for instance language, cultural heritage and practical skills. These knowledge forms were closely linked, and they occasionally overlapped. The knowledge revealed a worldview that gives acknowledgement to relationships and interconnections of the social, physical and spiritual worlds (Dei et al., 2022). I present these findings habitually in the form of direct quotes from the participants, although some may have been grammatically edited for clarity. I selected these quotes based on their richness and representativeness of community views (Khupe, 2014; Nyumba et al., 2018).

6.2.1 Language

The dialect for vaUkwangali in which knowledge is transmitted is predominantly Rukwangali. However, the other minority languages like Runyemba were also used to share knowledge, particularly when prompting the ECMs. In Ukwangali, the commonness of Rukwangali could be one point of hope for the preservation of IK. In this regard, the language alone communicates much traditional wisdom and knowledge, and young people are still capable and willing to communicate in their vernacular language of Rukwangali (Li & Tomasello, 2021).

In this study, the Grade 10 Physics teachers were thus allowed to have discussions in their home languages when interacting with the ECMs while at the same time observing the science aspects embedded in *drum making, drumming, music* and *dance*. In this regard, Kaurungi stated that: “*This study challenges if the similar observation could be made in Ukwangali community if communication in Rukwangali were to be given a chance in science learning*”.

Similarly, wisdom and knowledge in Ukwangali are shared either through songs and dance or storytelling as reiterated by Lavallée (2009). Stories and songs in Ukwangali play a pivotal role in teaching young people about Ukwangali discipline and values. In addition, the vaUkwangali

names suggest a social level; values such as relationships, harmony and gratitude are encouraged. For instance, some of the names such as *Namutenya*, *Hamutenya*, *Nangura* and *Haingura* also suggest the people's closeness to nature and the spiritual realm, the time of the day. For instance, *Nangura* and *Haingura* refer to morning, whereas *Hamutenya* and *Namutenya* refer to noontime.

6.2.2 Cultural technologies

The ECMs involved in this study reported that stories, traditional dance and songs as well as rituals, are associated with consulting departed ancestors who are regarded as part of life in Ukwangali as accentuated by Winkelman (2021). In this regard, loyal families perform some rituals by slaughtering a black cow and consulting their ancestor queens and chief-*hompa* in requesting for the rain to fall which is called *Kuzamba*. However, some practices seem to have been more dominant in the past than at the time of this study.

The Ukwangali idea of agricultural development is that the vaUkwangali survive on subsistence farming in their communal land. The community of Ukwangali has various indigenous technologies or practices adapted for use by smallholder farmers who know which can be fully developed. Onane Mukwangombe, an expert community member who was involved in my study, had the following hope in the Ukwangali Traditional Authority (UTA):

Etamburo lyelitjindjo mpepo mosirongo saUkwangali kunomena ekandano unkundi woruteni. Sinka po sosinene pokuhagekesa po elitjindjo mpepo, ntudi vaUkwangali va zangure unene. Eyi yaninkisa egendeso lyaUkwangali lipungwise moUmisiteli woUnandima, Mema noWiza pokugava evhu lyokusika konomusunda 18000 vatulise po sikunino pomukunda gwaZone konyara ure wonokilometa 40 komuzogo-utokero waNkurenkuru. Simpe vatungi mo kuna kusindindira sitakameke. [Thus, the need for climate change adaptation/mitigation in the Ukwangali community, and measures to combat vulnerability. The major task of climate change adaptation and mitigation in agriculture of Ukwangali is to produce more food efficiently. Hence, Ukwangali has to invest in Green Scheme projects by giving land to the Ministry of Agriculture, Water and Forestry to be used for the establishment of a Green Scheme project. The 1 800-hectare piece of land is situated at Zone village some 40 km north-west of Nkurenkuru. Yet, the community is waiting for its commencement].

The community of Ukwangali through the Ministry of Agriculture, Water and Forestry promotes various adaptation measures in its effort to curtail these challenges, for example, establishing a livestock auction pan called MpasiNkuru at Nepara Village in the Mpungu constituency of the Kavango West Region and administered by the district farmers association as shown in Figure 6.1.



Figure 6.1: MpasiNkuru Auction Pan for the vaUkwangali community

It could be argued, then, that the knowledge of Ukwangali has natural, historical, socio-economic and even spiritual connotations. The people value their community. They have a sense of belonging despite the encounters they face (Dawson et al., 2021).

6.2.3 Practical skills

Practical skills are another form of knowledge that came through in the interactions with the community of Ukwangali. Khupe (2014) defines practical skills (knowledge) as “the ability to make or do things” (p. 129). For this study, skills vary according to gender. For instance, men make things from animal skins, wood, metals, reeds and horns, whereas women work with grass, beads and clay (Mateus & Ngcoza, 2019). The items that I saw in the homes of the ECMs at the time of the study include reed mats-*erwarwa*, clay pots-*kandimbe*, rattle-*rudeve*, axe-*nzimbu*, arrow and bow-*uta wonkanza*, axehold-*mupini*, chair-*sipundi* and sledge-*sireyi*” (*Nda-Kulanda*).

Common practical skills present in the Ukwangali community among others are the making of axes by blast furnace (Kudumo, 2020) and drum making (see Figure 6.5). Regarding malleability, Otate Matia stated that:

Kuhambura nozimbu nonombere kapisi kulikida tupu udivi weli ke. Ame kukwanena mo yiwiza mo pokureresa ko epata lyange. Siruwo soku teza vantu kuhepa nombere dononzi yeeyi ado nontwe yiyo hena dakara nomulyo unene [Making knives through a blast furnace is not just a demonstration of skill. It is one of the sources of income to eradicate poverty. During the harvesting, many people need these types of knives for harvesting because they are sharp and of quality].

The excerpt above shows the significant power in the recognition of the contributions of the knowledge of indigenous peoples and local communities to human development across diverse disciplines, especially in the environmental and life sciences (Oguamanam, 2021). The skill of weaving is relevant prior knowledge in the curriculum of arts and design of the junior secondary phase as well as in arts and technology in both junior and senior primary education.



Figure 6.2: Women weaving grass

The knowledge of weaving (making of baskets-*sikumba*) is passed on as an inheritance from the older generation to younger generations (Kakambi, 2020). Although the main focus of the study was on *making drums, drumming, music and dance*, this activity provides a much-needed context for learning science. It is against this background that Kakambi (2020) investigated the use of the

indigenous technology of dyeing and weaving baskets as a cultural tool to mediate learning of chemical and physical changes in Physical Science Grade 7-9.

The ECM embraced and valued the indigenous technology of dyeing and weaving as relevant and useful in teaching and learning. Also, the Unongo Youth Cultural Group used the artefact of baskets to demonstrate the uses of the cultural dishes when performing the traditional dance and music. In doing so, the activity ensures the women of Ukwangali spend their time on these tasks and share ideas related to decision-making, rather than being at the Shebeens and drinking *mundevere* (cultural brewed alcohol).

6.3 Data from the ECMs During Drum Making

Presented below is the data gathered during the practical demonstrations and explanations given by the Unongo Youth Cultural Group – the community experts on *drum making, drumming, music and dance*. This was intended to answer the following research question:

How do the Grade 10 Physics teachers interact, participate and learn (or not) during the ECMs' practical demonstrations and explanations on drum making, drumming, music and dance?

Before the ECMs started with their demonstrations and explanations about *drum making, drumming, music and dance*, the Unongo Youth Cultural Group told the Grade 10 Physics teachers that there are two different types of ngoma-drum as emphasised by Otate Matia:

1. *Ngoma zokusika* [Ngoma for drumming, music and dance as a musical instrument].
2. *Ngoma zononyiki* [Ngoma as a bee trap for beehive].

A bee trap is used by the community to keep beehives to harvest honey. Honey in the community is used for *Ndoka* or *Vingundu* in Runyemba (a locally brewed beer from bee honey). It is preferable in the early morning or late evening when elders are telling stories or assigning responsibilities to members of the family – division of labour.

6.3.1 Carving of musical instruments: Ngoma

In the Ukwangwali community, there is a collection of different musical instruments. For instance, the Unongo Youth Cultural Group in Yinsu Village is skilled in making musical instruments, such as *ngoma*. The construction of musical instruments involves a wide assortment of techniques that employ different materials that are found in the environment. This suggests that these are easily accessible materials (Asheela et al., 2021). The materials that are used in making *ngoma* include parts of plants (trunk) and animals' skin (see Figure 6.3).

The sizes of *ngoma* are selected for their effectiveness in performing different types of music or sound; for example, *epera*, *Unyanga*, *Ukambe* and *Makopo* cultural dances for producing specific melodic purposes. The process starts with the top head and ends with the bottom head as shown in Figure 6.3.



Figure 6.3: Trunk from a Mangetti tree being perforated for a drum - *Ngoma*

The drum is made of a hollow cylindrical drum with two heads. For instance, Otate Matia explained that: “*Kutura ndi kudika sitji mevhu yipo siyukilire ntani kukwafa muhongi atete nawa oso sitji sene ta si hongo*” [Put the trunk on the ground for positioning it which enables the carver to cut the trunk when hollowing the drum-*ngoma*].

The axe is used for cutting the trunk from its tree and it is considered to be the basic tool in making a drum. The carver uses a gauge with a long handle, about 1m long when carving inside the drum to deepen it as shown in Figure 6.4. The size of the hollow side depends on the type of drum one wants to make as well as the type of dance.

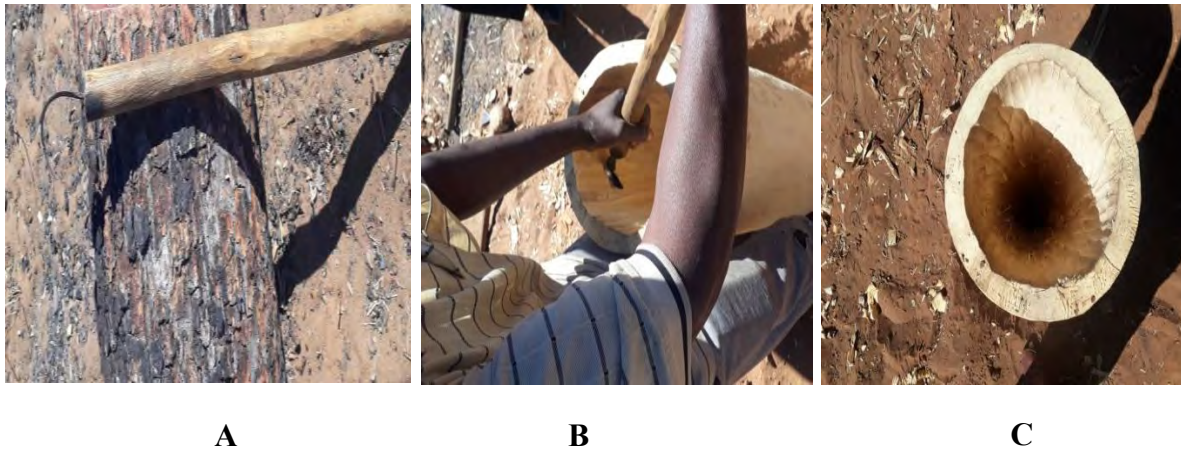


Figure 6.4: The head (hollow side) of the drum

In Figure 6.4A, the hooked knife gauge is used to scoop out the convex surface from bowls. The hook knives are sharpened on one side and considered right-hand versions designed to be pulled towards the carver. It is designed in such a way to allow working in the hollow not otherwise accessible with a straight blade. Otate Matia explained that he considers the hook knife as the final cutter when smoothing the hollow side of the drum as shown in Figure 6.4.C.

The process of *drum making, drumming, music and dance* is associated with the cultural interaction that normally occurs between people of different ideas, languages or cultures when they come in contact with one another. In this regard, without such a facility for observation and discussion cultural integration would be impossible (Ogunniyi 2007a). It is for that reason that CAT states that two ideas or states of mind tend to readily compete, argue and dialogue with each other to create a greater form of consciousness (Ogunniyi 2007a).

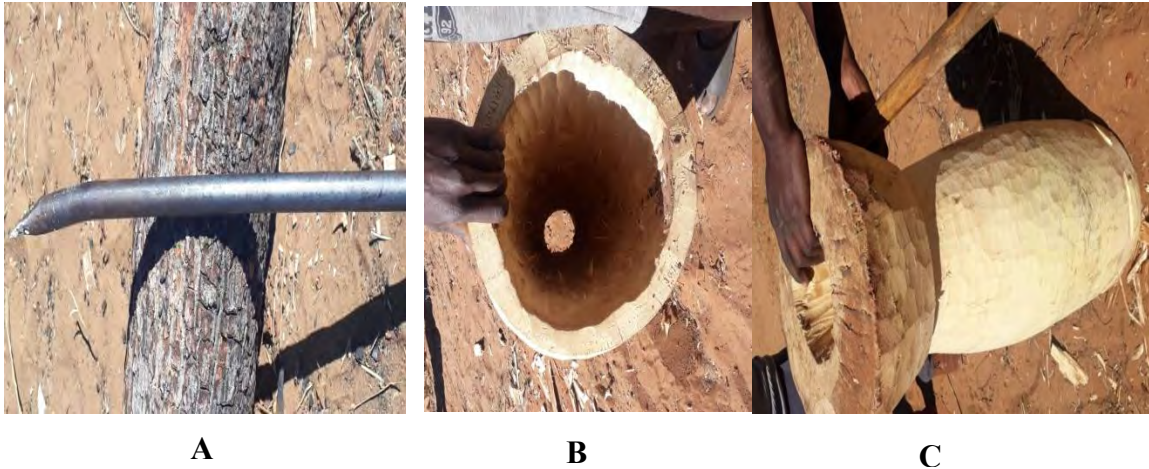


Figure 6.5: Hexagon chisels (*Etwiso*)

In Figure 6.5A, the tool is used by hand for cutting wood. This type of chisel is a tool with a characteristically shaped cutting edge blade on its end, for carving or cutting a hard material such as wood by hand, struck with a mallet or mechanical power. The Physics behind this process is that it has a flat edge to enhance the pressure since its area is so small. Hence, the hexagon chisel is used to chop the trunk when perforating a block of the trunk for the drum as shown in Figures 6.5B and C. During the demonstrations by the community members, the Grade 10 Physics members asked some questions such as:

1. *Why is a drum made of this specific tree called Ugongo or Uguva?*
2. *Why do you choose to use skin from a goat or cow?*
3. *Why do the two drumheads have different sizes?*

The carver or drum maker was Oate Matia. He had this to say in response to the questions: “*Ngoma kuzihonga kougongo, ndi Uguva morwa yiso sitji sosireru sene sakukuta*” [Drum is made from two types of the stem from *Mangetti* and *Pterocarpus angolensis* tree because they are light when they are dry].

Cylindrical drums are commonly two-headed and straight-sided as shown in Figure 6.4. The drum is handcrafted using traditional methods and a solid wood frame wrapped with durable cow or goat skin (Liveve, 2017) (see Figure 6.6). The trunk from the *Mangetti* tree or *Muwowo* or *Pterocarpus*

angolensis tree seems to be suitable for a drum since it loses water gradually without cracking and that could be used to mediate learning of osmosis (Shahonya et al., 2021). In this regard, Otate Matia emphasised that:

Nomufa kuninkisa muhagaro gezwi gusesupe komeho likapwagere ketako lyo Ngoma. nawa nawa, nomufa kusesupi ka mulyo gezwi lyo Ngoma. Ado kuvhura dudisesupika moku kwita Ngoma kuruganesa mahokwa gokukanga ndi kuzikwita yihemu yosera [Cracks lead to the reduction of sound before it passes through the sound tunnel. Moreover, cracks reduce the quality of sound when emitting through the drum cylinder. These cracks are prevented by coating the drum with baked nuts of Mangetti or lubricating the drum with candle waxes].

From the excerpt above, we were made to understand the best trees that could be used to make drums and why. Oil from magnet nuts is used for oiling and plays a major role in drum making, for instance, it helps to keep the drum hydrated and attractive. Normally, in a cracking drum, the vibrations that make drumheads sound would not travel the same way through the sound tunnel. The size and length of a drum have a great influence on the quality of sound produced. Perforated trunk blocks are one of the most common forms of material used by these community members. The main purpose of the perforations, or holes, is to increase the motion properties of longitudinal waves in the block walls. Perforations also make the blocks lighter and easier to handle on-site and reduce the total mass. In this regard, Otate Matia explained that: *“There are two layers that occur for drum walls with thickness wall, trim waves and echoes than that of the thin wall”*.

For the sound to travel across the wall depth, the compressions and rarefactions of the sound may be influenced by the thickness and thinness of the drum during the perforating of the block. The carver should bear in mind that the quality of sound is determined by the wall of the drum made (Otate Matia).



Figure 6.6: Preparing the drumhead membrane

Figure 6.6 above shows the drum maker preparing the membrane by wrapping and stretching the skin over a solid wood frame. Answering the second question during the demonstrations and explanations, in this community, a drum is a musical instrument that produces sound from the vibration of the stretched membrane. According to Otate Matia, “*Ose momukunda kuruganesa sipapa sosikombo ndi songombe. Morwa kukwama kounankondo wa so nompuzo za so*” [We in the community we use the skin from a goat or a cow. It depends on its quality and thickness].

Culturally, the membrane is known as the drumhead; the maker covers the one end of a hollow body as the shell. The skin should be soaked in water and hairs are removed by using a sharp knife (see Figure 6.9). Otate Matia explained that: “*Sense sipapa vadira kusigusa nohuki, kusesupika elinyungangango lyosipapa, kureta pokatji kosipapa nosikande ko ntani sipapa kapi tasinanunu ka unene*” [If hairs are not removed, this reduces the vibration of the skin, creates moisture between the palms and skin cannot be stretched well as required].

The tightened skin vibrates higher than the loose one. The skin is held by pegs which are placed in the holes made with bradawl as shown in Figure 6.7.



Figure 6.7: Using bradawl-*Munho* to drill a hole for pegging

In Figure 6.7 above, the bradawl is heated by using a blast furnace-*Mudukuto* (Kudumo, 2020). This is useful for making holes around the drumhead and pegs are placed into the grip and stretch the skin around the drumhead. The skin should be soaked in water first to make the tanning process easy. If the drum shells are thick enough, attaching a skin small wood pegs can be used (see Figure 6.7).

6.3.2 Tanning skin for drumhead

According to Otate Matia, tanning skin is the process of preparing raw animal skins with or without fur. Raw animal skin is untreated, scraped to an even thickness, stretched, and then left out to dry. Alternatively, the Unongo Youth Cultural Group's way of tanning skin is an easy and cheap natural method of soaking raw animal skin in saline solution (salt water) for about two days or more depending on the temperature of the water. The skin is then placed in the shade, laying it completely flat with the fur side down, preferably on a cold rock or hard surface. When the skin feels cool, the fleshy side is completely and immediately covered with wood ash to avoid the skin's flesh from getting dry and bacteria from attacking the skin as explained by Otate Mukwanzovhu.

Then, the flesh is scraped off the skin for making the drumhead. Gradually, a drum maker covers the top side of the drum with the skin and then shaves it after it has been mounted. It is an arduous job, but mechanically it is pretty simple as shown in Figures 6.8 and 6. 9.

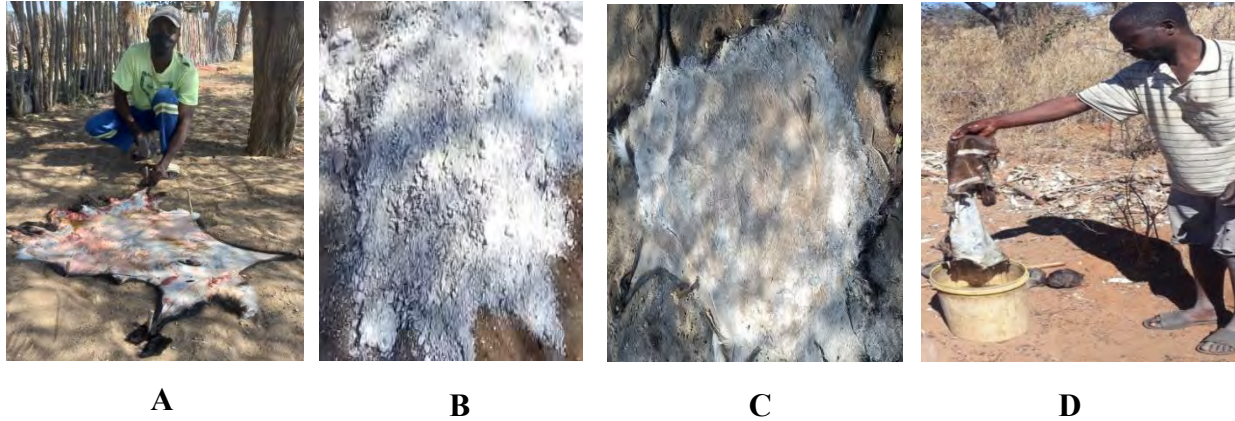


Figure 6.8: Making tanned raw animal skin by soaking in water with salt or wood ash

As shown in Figure 6.8A, above, skin is placed in the shade, laying it completely flat with the side with fur preferably on the cold ground. For instance, Otate Matia explained that: “*Nsene tupu sipapa sizuvhika asi satende pokusikwata makura kusirange ka nokusikwita enotoand kusitupi ka momema gomungwa yipo sawora konondi*” [Once the skin feels cool to the touch, immediately cover the fleshy side completely with wood ash or salt to avoid it being spoiled by flies] (see Figure 6.8C).

In the process, pegs are used to hold the skin to prevent it from shrinking (see Figure 6.8A). To get rid of hair from the skin, it should be soaked in water with salt or wood ash (see Fig 6.8D). Meanwhile, Nda-Kulanda added that wood ash (Figure 6.8B) protects the animal skin by reducing its moisture content since the micro-organisms need a certain amount of moisture for their activity. That is the reason why Otate Matia soaked the skin in water with wood ash or smeared it with ash to prevent it from becoming rotten. It was observed that the process enabled Otate Matia to scrape the surface off the skin easily.

It was revealed that the skin has to be tanned to prevent it from turning rough when it gets moistened by sweat from the players' hands. This difference in wood ash concentration creates a concentration gradient between the outer and inner parts of the animal skin which causes the transport of water molecules from the inner cells of the skin to the external parts of the skin through the cell membranes via the process of osmosis (see Figure 6.8C). Hence, the loss of water activity from the inner cells of the skin results in the dehydration of the skin which slows down decay. Otate Matia further explained that: “*Kumyasa sipapa, kusininkisa sikandane mema, sipame nampli ngano musiki tasidaya unene mukumo*” [Tanning makes the skin to be a waterproof material which improves its durability even if the drum is hit hard] (SRI).

The purpose of tanning skin into leather involves a process that permanently alters the protein structure of skin making it more durable and less vulnerable to decomposition. It was observed that the process loosens the hair and softens the membrane layer, which is later scraped off. It is only ready when the fur can be easily pulled off from the skin with a firm object.

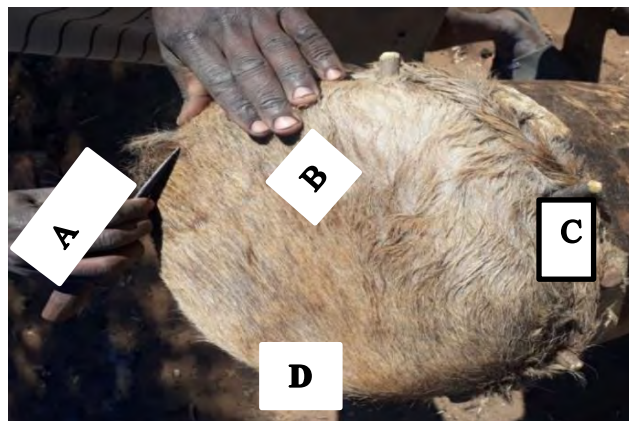


Figure 6.9: Shaving the skin after being mounted over a drumhead

The skin is shaved by using a blunt or sharp edge. Once the hair is scraped off the skin, this ensures that the skin is wrapped over the drumhead properly. Removing the fur from the skin increases the contact force between the palm and the skin. Furthermore, extra special care should be taken where the edge meets the skin by using light pressure (pressing the edge slowly). In this study, the parts labelled above represent the following:

- A- *The firm knife is used for shaving hair off the skin to increase the rate of vibration of the membrane when hit during drumming.*
- B- *Drumhead ring to clip skin around the hollow.*
- C- *Small wood pegs called buttons are driven into a drum shell to secure the skin on the drumhead.*
- D- *A membrane covered with hair reduces the speed of the skin vibration once hit.*

At this point, Otate Mukwanzovhu explained that the skin with the hair produces a rather dull sound when the drum is beaten. Similarly, the thin skin also tends to have an annoying ringing sound and breaks faster. It is thus recommended to choose a medium to thick skin depending on the type of drum.



Figure 6.10: The shaved skin around the drumhead

In Figure 6.10 above, all fur on the face of the drum has been removed using a blunt or sharp edge until the whole face and edges are smooth and clean. The skin is mounted over the drumhead and the skin should be protected from excessive water staying on the skin layer. The skin can absorb water which can spoil it, and the quality of the skin can be affected resulting in it not lasting long.

6.4 The Physics of a Drum

A drum skin is a membrane stretched over one of the open ends of the drum. The vibration of the head drum and/or the membrane compresses the air inside the shell. It was observed that these vibrations of the top head create vibrations in the air which become sound. In the community, the

common source of sound is the wooden block drum-*ngoma*. When it is beaten it vibrates to produce sound – the cone vibrates producing a series of compressions in the air and behaves similarly to what is shown below.

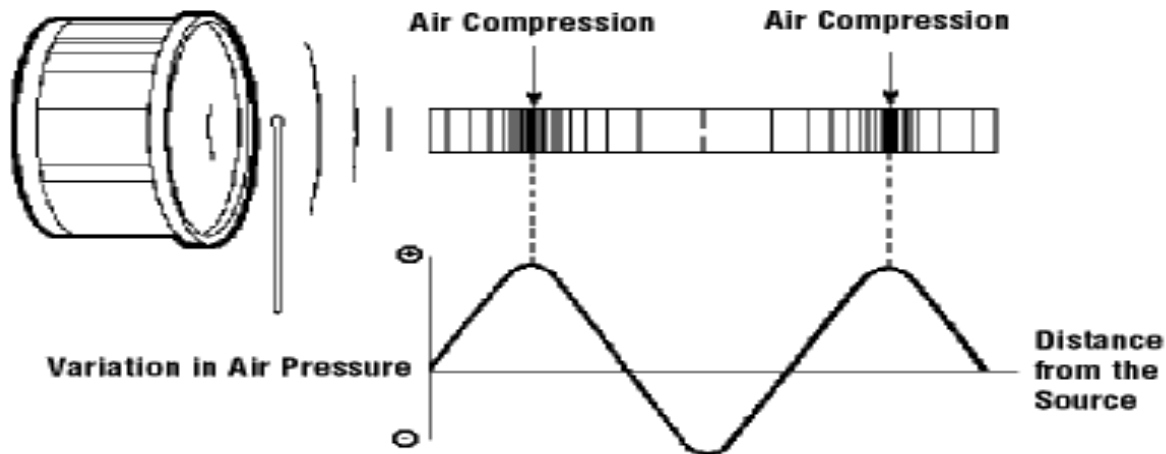


Figure 6.11: Transmission of sound from the source
 (https://www.ccohs.ca/oshanswers/phys_agents/noise-_basic.html#figure1)

These are called *longitudinal progressive waves*. Logically, the oscillations happen in the same direction that the wave is travelling. The sound waves are produced to enter the ear of the dancers. However, sound can only be transmitted through a medium and cannot travel in a vacuum. The frequency of sound waves relates to pitch. Notably, a drum has specific properties that influence the effect of sound. In Physics, for instance, the following factors affect the quality of sound production: the size of the hollow side of the drum, the thickness and thinness of the skin, and the type of skin used in wrapping the hollow.

6.4.1 Explanations from ECMs on the size of the drum hollow and shell

It was reported that a drum is a percussion instrument of which there are numerous types, including *Nkurugoma*, *Nkinza ntani zomatjakili*-bass drum, alto and tenor drum said (Otate Matia). Most drums consist of a hollow wood cylinder with stretched skin over one side. Sound is produced by beating the skin with the palms of the hands. In this regard, Otate Matia, the drum maker, explained that: “*Kwakara ko maruha gonoNgoma gokulisigasiga kuhamena mounene wado ago kuninkisa*

mulyo gezwi eli nali pwagesa ngoma moomu tupu vadilikida” [There are various ways of drum size that affect the quality of sound produced] (see Figure 6.12).

The excerpt above illustrates that the smaller the diameter of the drum, the higher its pitch. That is, if the drum player is using a drum with a diameter of 30cm, it would produce a deep sound, while on the other hand, a drum with a diameter of 20cm would produce a high pitch sound.

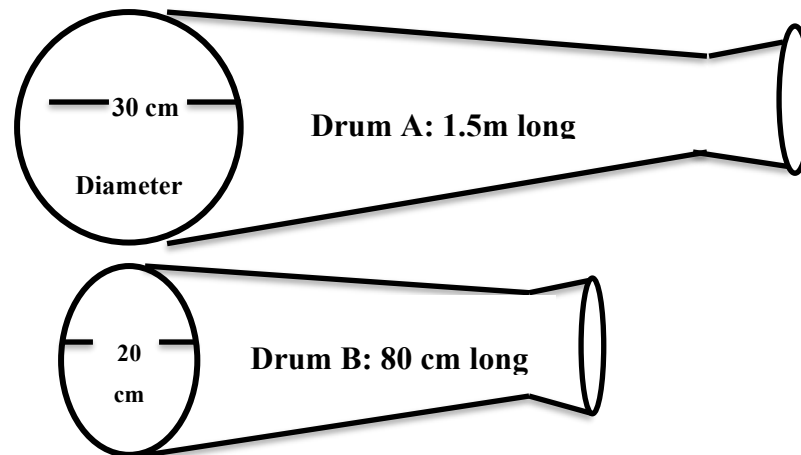


Figure 6.12: Shows two drums with different diameters (<https://r.search.yahoo.com>)

In response to the third question asked by the Physics teachers, Otate Mukwasipika elaborated: “*Ngoma zonene nkenye apa ku gava ezwi lyenene kuvhulisa Ngoma zonunu*” [A larger drum always would be louder than a smaller drum].

Regarding materials used – thickness, head type and drum depth – all of these can affect the volume and sound of a particular drum. The different sizes and their resulting sounds are usually designed to cater to a mechanical benchmark.

6.4.2 Explanations from ECMs on thickness and thinness of the skin

The Grade 10 Physics teachers during and after the demonstrations and explanations by ECMs seemed to have some understanding of IK. In this second factor, Otate Matia explained that *sihagaro*-the pitch of a drum can be manipulated in three ways:

1. *Kukokera sipapa songoma, kuninka ezwi li ze keguru* [Tighten the drum's skin to make the pitch higher].
2. *Kuruganesa sipapa sompu zonene kuninkisa ezwi lisesupe* [Use a thick skin over a drumhead to lower the pitch].
3. *Kudayera Ngoma pokatji kuninkisa sipapa sinyungange kuliwora ntani muhagaro gezwi kudama* [Strike the drum closer to the centre to produce a slower vibration and lower pitch that sounds more resonant].
4. *Kuruganesa enongo yipo yipangere ezwi* [Use mould clay-*enongo* placed at the centre of the drumhead as a sounder controller].

Professional drum beaters seem to use a variety of approaches in making different sounds. The mechanical principle of the drum is that the waves move out from the drum's membrane resulting in the making of the sound. In this case, it is the wave that moves in a direction that is parallel to the drum which is known as a longitudinal wave. The term pitch relates to how high or low a sound is. For instance, when one hits a big drum, it makes a lower pitch than a small drum might. Therefore, a drum with a larger drum surface area (drumhead) takes longer to move back and forth, creating lower vibrations or oscillations and hence a lower pitch. Again, if the drum maker makes a thicker or looser surface for a drumhead it would also take longer to move and would make a deeper sound. Customarily, wax-*enongo* is placed on top of the drumhead's surface in a ring form. This makes the skin vibrate slowly and a lower pitch is made. Usually, beeswax is appropriate for the bass drum called *Nkurugona* (see Figure 6.12 below).



Figure 6.13: Wax (*Enongo*) for altering the pitch

The wax should be warmed while it is on the drum's surface which refers to a diaphragm cone to enhance the tension hoop of the skin and allows the skin to stretch flexibly. Essentially, drummers often wax the centre part of the drumhead, which is useful in improving the sound, particularly the bass, and makes tuning easier.

6.4.3 Explanations from ECMs on the type of skin used in wrapping the hollow

The drum is a wonderful and emotional instrument from ancient history until today (Dean & Mgrdichian, 2021). In this regard, Onane Mukwangombe commented that: “*Nadimburura as Unongo wange wokuhamena kusika nokudana ntani yompo sakara mulyo unene*” [I have come to realise that my knowledge of the drum making, drumming and their histories is as important as my technical ability to strike the drum] (SRI).

The drummer further explained that for all tones he was able to play, the decision of what to play and when is just as pertinent. The drumming must be able to direct the dancers for the tempo of the song they might sing as explained in Section 6.5.2.

Moreover, the melody is determined by the type of skin used in covering the hollow side of the drum as it also affects sound production. In the community where the study took place, the skins available were that of goats or sheep, cows-calves and antelope. Drums should be sorted from high to low pitch which depends on the type of skin and its flexibility. In the next section, I present and discuss the data revealed during *drumming, music and dance*.

6.5 Data from the ECMs During Drumming, Music, and Dance

In this section, I present the data from the community members during *drumming, music and dances*. After-school programmes have mutual benefits for the school, the family and the community since the majority of the Unongo Youth Cultural Group members were schoolgoing children. It was concluded that considering the community of practice in planning the after-school science activities could have a positive influence on Grade 10 Physics teachers' attitude towards learning science imbedded in the indigenous technology (Agunbiade et al., 2017). The study population consisted of young adult men and women (average age 21–32), four men and six women. It was led by an experienced ngoma drummer whose responsibility was to play the bass note drum. He was supported by other young men in beating two other drums, while women sang

and clapped hands supporting the drumming for a specific rhythm which I explain in the next section.

6.5.1 Drumming techniques

Drumming plays a significant role in cultural traditions in this community and the African continent for many centuries specifically the discipline commonly known as *ngoma* drumming. In this study, *ngoma* drumming is a form of drumming known for its rhythm and is commonly used for cultural celebrations and rituals as well as for communication purposes. This intervention was planned for Grade 10 Physics teachers to learn the science embedded in the indigenous technologies in order to use them when co-developing exemplar lessons on the Grade 10 Physics topics.

In the course of drumming, the drum must be held at an angle or clamped with both legs and secured with a rope around the drummer's waist. This allows for a relaxed playing position and also allows the sound to come out of the drum through the bottom end. The position of the hand that hits the skin is crucial both for the sound and ease of playing. The bass tonal drummer Otate Matia explained that: "*Mukumo gedayeso kutunda kepepe pokuruganesa sikande ko pakugendesa ku woko nourerureru*" [The strength for drumming is supplied by shoulders and using the palms for the main movement with a flexible and relaxed wrist].

To achieve higher or lower tones, a drummer uses the left hand in the centre of the drumhead for a low sound and the right hand on the edge for a high sound. Moreover, lower tones come from the centre of the drumhead membrane using a slightly cupped palm with the area of contact all around the edge of the hand, while fingers are together but relaxed. Essentially, a drummer allows the hands to ricochet from the drum so that the sound is not diminished. Another skill for hand drumming for sound is a slap. In this skill, the thumb is away from other fingers. The palm contacts the edge of the drumhead as shown in Figure 6.13 and the four fingers strike near the edge making contact with the drumhead at about 45-degree angles using the pads of the fingertips. That results in a loud pop sound. In this manner, the volume comes from a snap of the wrist instead of from the force exerted by the hit. The drum pattern is a rhythmic pattern established when a drum is beaten with a hand by the drummer. Onane Mukwankora explained that in drumming, the below skills should be mastered by all drummers for specific dances and rhythms:

- *Kuzanza yikandeko, nokulitura ntani kudayera Ngoma pokatji pwene ntani* [Open tones are produced with a relaxed flat palm hitting the drum just off-centre].
- *Ezwi lye peguru guru kuliretesa po nsene musiki tasikire kouhura wononyara* [High tones are usually made by striking the drum with the fingertips very near the edge of the drum] (SRI).

Often, *ngoma* is a hand drumming musical instrument which can rest on a stand that can be adjusted for either a seated or standing position. Striking is mainly comfortable if the drum is worn to make it possible to move around while drumming and the stand bottom is always open to allow the sound to emanate from the drum.



Figure 6.14: Shows palm position for bass

It was revealed that to make the bass sound the drummer should drop the palm, with fingers up, near the centre of the drum and bounce off giving a deep resonant bass tone as shown in Figure 6.14. It should be noted that the bottom of the drum is open for getting a resonant bass tone. Moreover, cracks in the drum no matter how small may diminish the bass (as explained in Figure 6.6). During drumming, *ngoma* can make tones if the full length of the fingers held together hit about one-third of the way to the centre and bounce off. Hence, a full, warm medium pitched sound is similar to the finger open tone in Figure 6.15. There is a variety of skills for beating drums by using different slaps, namely *open slap*, *closed slap*, *mute slap* and *finger slap* as highlighted by the experienced drummer as explained below.



A

B

C

Figure 6.15: Shows palm position for open, closed slap and for finger open tones

The technique in Figure 6.15A is one of the easiest sounds to get from the drum and is considered to be the dominant sound of the wooden block drum known as *ngoma*. Hands should be naturally relaxed and slightly cupped in shape. Normally, a drummer strikes the drum skin by contacting the rim with the muscle between the base of the fingers and palm towards the outside edge of the hand. The skill in Figure 6.15B is similar to the open slap stroke, however, the fingers should remain on the drum. It always gives off the tones of “pah” “pah tah” – “pah” “pa tah” and “puh nduh”, “puh nduh”. This type of close slap gives a signal to the singers and dancers for any pattern. This stimulated Physics teachers to participate in learning how to play the drum.

The skill in Figure 6.15C shows a slap tone made with the full length of the force through fingers spread and is struck approximately one-third of the way to the centre and echoed. Next, I present and discuss the data from traditional music and dance in phase 2 of the study.

6.5.2 Traditional music and dance

Traditional music and dance are cultural activities enjoyed by most people in rural communities of Namibia, especially in the community where my study took place. Both Grade 10 Physics teachers and community members were present to watch the singing and dancing of the Unongo Youth Cultural Group during the intervention. The parents from the community were self-invited

and many of them were parents to the youth in the Unongo Youth Cultural Group, who ululated²² during the traditional performance. Some even sang along. The Physics teachers were encouraged to sing the common songs and to also do dances such as *epera*, *Ukambe*, *Unyanga* and so on. In the interview, Otate Mukwangombe explained that: “*Ame kwakulizuva uwawa pokumona molyo gompo gumone ke mosingwa sonsitwe*” [I have enjoyed seeing the value of their culture to science curriculum] (as shown in Figure 6.16).

The drumming and dance are not only to grasp the importance of community but also to inspire both Physics teachers and ECMs to share their own experiences about overcoming barriers in life as emphasised by Collins (2021). In this regard, sense-making is strongly influenced by children’s socio-cultural contexts of learning (Cycyk & Huerta, 2020; Mavuru & Ramnarain, 2020; Vygotsky, 1978), which includes culturally informed beliefs, and values and practices of their parents.



Figure 6.16: Traditional music and dances performed by Unongo Youth Cultural Group

²² In the context of the study, a high-pitched, rhythmical sound is an expression of joy and celebration.

The songs that go together with the dancing describe the distinctive cultural rural living style such as housing by using thatch for roofing, medication and transport.

In music, songs are used for rituals to calm spirits, both good – marriage, coronation, menstrual, circumcision and harvest – and death announcements for kings or queens, burials, healing and so forth. On these evenings, all members of the community, that is, elders, women, men and children, would sit around the fire initiated by the heads of households or head men to listen to stories and songs. The quantity and quality of stories and songs that the gathering possesses would vary according to age, gender, socio-economic status, daily experiences, roles and responsibilities in the home and the community and so forth (Chilisa, 2012; Lavallée, 2009).

Songs also are made for celebrations, to tell stories about subsistence and achievements. This conversation has been described and fits well with Sylvester et al.'s (2020) study which explained the indigenous method that honours the oral nature of knowledge sharing. Traditional musical instruments are used in ceremonies and to communicate with the spirits. The instruments are made from local raw materials found in the environment. In this regard, Onane Mukwanzadi expressed that:

Ngosihonene, moUkwangali moruha sirongo Kavango utokero ose kuzuva marudimbo gomomaraka goRukwangli, Runyemba nagamwe ngwendi Rusiwokwe ngoso vana vhongo nomarudimbo go kulisiga-siga ngwendi goRash ham, gongereka, disco nangoso aga aga ruganesa yidimbo yompo yipo yiranye vantu wo nompo dokulisiga-siga [For example, in the Ukwangali community of Kavango West, we hear folk genre music sung in vernacular languages such as Rukwangali, Runyemba and other minorities of Rusiwokwe mixed with pop, reggae, rap, gospel, disco and other genres that use traditional instruments to make the music attractive to people of different cultures].

From this excerpt, it could be surmised that in the Ukwangali community diversity is celebrated as reiterated by Snyder-Young and Flassen (2021). Many instruments are not listed above and are commonly used in the community for complementing their music, dance and drumming. According to Tate Matia, the group composes songs about the function or event as needed. The dances and singing should give out information that addresses the current situation. In this regard, he commented that: “*Sene vatuzigida neina twakona kupitisa po rusumo rwa kugava erongo lyahamene Corona*” [If we are to be invited today, the group must compose at least a song that relates to the Corona awareness].

In this study, traditional or folklore music is a community heritage that plays a role in helping people understand the community better. Resultantly, the cultural imperatives of grassroots communities are honoured as reiterated by Buras (2021). Music represents the history, traditions and thoughts of a community. The Unongo Youth Cultural Group, for instance, plays an important role through songs that are created in a common manner which have continued from the time of their production right up to the present day, and are popular and frequently played and related to their locality. Traditional music usually has four characteristics:

- It is transmitted through an oral tradition.
- The music is often related to community culture.
- They commemorate historical and personal events.
- They transform folklore music or songs into contemporary folk music or songs.

Admittedly, music cannot be separated from dance. Moreover, dances play a vital part in the culture of the vaUkwangali community. Some dances describe different elements of nature, such as the rain dance. Many dances, such as those that imitate animal movements in particular horses, are usually performed. There are also dances which describe the vaUkwangali's way of life, such as the inauguration of a chief-*homba* as emphasised by Arowolo (2022).

Most importantly, the traditional dances of this community represent other cultures in a way that tells other people about the things related to other cultures or what they need to know about their own. It is also the way that other people could have respect and knowledge, and give importance to the traditions and norms of other cultures – as reiterated in Lavallée (2009), that the primary negotiations for the research framework should reflect the customs, beliefs and practices of the groups. For instance, Onane Mukwanangandu commented that: “*Pulisireni nompo dimwe ditante nokulikida eyi ya vanda mwado*” [Let other cultures tell what stories are behind their dances]. Such a dance is somehow different from other forms of dance as it has a story behind it for the purpose of sharing that culture with other cultures. For instance, the community in this study has a dynamic dance, with colourful legs and customs, and slow and fast movements gaining the attention of everyone.

In the community, dance is always accompanied by the beating of drums, hand clapping and rattles. If drums are beaten continuously, then people would know that a certain homestead or village is inviting everyone to come and share anything available, for example, food, drinks and/or information or news from the elder council or palace. During these demonstrations and explanations, the traditional dance is the product of cultural behaviours created by inhabitants living in that community and/or the Ukwangali community in the Kavango west region of the northern part of Namibia. Moreover, Onane Mukwangombe reflected that: “*Ou udano damu-damu ngwendi gaaga gamwe gakara noyipo ntani sivaro sovadani, mudwaro noyili ka eyi nava kadanena kapi yapulisira vakayidware poudano ukwawo*” [This dance is just like every other which has its special characteristics, like who is allowed and who is forbidden to perform the dance, the number of dancers, attires to wear and what kind of events a dance should be performed].

It could be argued then that the community culture seems to have a twofold role, viz. as part of the identity of local communities and as a unique attraction for tourists, thereby influencing, complementing and strengthening each other (Syafri et al., 2020). As a result, traditional dance is used as a way to promote tourism and local neighbourhoods and enhance the exchange of items as a token of appreciation. However, Onane Mukwanzovhu said that nowadays it is more difficult to find individuals, particularly young people that are committed to maintaining traditional culture and art since they all regard this as for the old age group. This finding seems to be congruent with Horsthemke and Schafer’s (2007) assertion that schoolchildren frequently reject the incorporation of “African” studies into the school curriculum, viewing it as “irrelevant, exotic, backward, and culturally alienating” (Horsthemke & Schafer, 2007, p. 5).

In most cases, dance is more than just exploring different ways to learn a series of steps to music. Instead, music gives a signal or pattern to the dancers that they can follow when performing any dance or movement – how fast or slow the movement could be. It was revealed that:

It is a way of moving that uses the body as an instrument of expression and communication. Dance enables learners to improve themselves and the world they live in (Onane Mukwambahu, SRI).

Moreover, Onane Mukwanzadi emphasised that: “*Udano yizo mpito zo ku tura rutu rupama, rwakangu ka rwa nkenye epupi yihwi ndi unene wendi pamundinda. Kuwapukurura epame ko lyononsipa, mutjima nomukumo gorutu*” [Dancing is a way to stay fit for people of all ages, shapes and sizes, having a wide range of physical and mental benefits. Improve muscle tone and strength and weight management]. Furthermore, Onane Mukwankora explained that there are some common notable and lasting values that dance lessons can provide for life: “*Kutulisa po uholi wanarunye*” [Lasting friendships formed; educational value; and having a loving hobby] (SRI).

Furthermore, the elements of dance are the foundational concepts and vocabulary that both learners and any individual members of the community use in developing movement skills and understanding dance as an artistic practice. In education, for instance, more comprehensively the art of dance develops kinaesthetic and spatial learning as well as interpersonal knowledge of self and others. On the other hand, dancers are more self-motivated, disciplined and focused on their everyday lives. Grade 10 Physics teachers learnt that sound vibrations travel in a wave pattern. The further away from the source of a sound you are, the waves lessen until they do not have the strength to vibrate any other particles. It is like when dancers move away from the sound source in this case the drum, they hear the quality sound as they move away that make waves lessen until it does not have the strength to travel anymore. Sound can move through the air, water or solids, as long as there are particles to bounce off. Next, I present and discuss the common dance that the community members of the Unongo Youth Cultural Group perform.

6.5.3 Data that emerged during demonstrations and explanations of traditional music and dances: *Epera*

The practical demonstrations and explanations made by the ECMs afforded the teachers involved in this study an opportunity to interact, participate and learn as reiterated by Vygotsky (1978) and Sedlacek and Sedova (2017) and other scholars. Notably, the dance may be open to all, or it may be an activity in which one, two, three or four individuals regardless of sex take turns in the dancing ring. It is done with the accompaniment of three drums, singing and clapping. The performance took place in an open space or ground and the community members were dressed in colourful attire.

Epera is a cultural dance that is well known since the olden days. This dance is normally performed during the harvest time to celebrate crops obtained during that year. Three drums (see Figure 6.14) of different sizes are involved in this dance that takes place at the royal family functions; it is also used during rituals. Women and men including the youth (boys and girls) come together to perform. The names of the three drums used during this ceremony are *Matjakili*-alto, *Nkurugoma*-base and *Nkiza*-soprano. They are played starting in the evening to the morning time and are followed by speeches.

After dancing, community members go and enjoy their traditional beer called *mutoho* or *muheturo* which is made out of Mahangu or sorghum grains. Essentially, *Epera* dance consists of relationships between movements as they occur in space and through time. Thus, dances have a spatial design as well as a time design (Gavish & Stevens, 2020). Traditionally, *Epera* is the Rukwangali term for celebratory and/or harvest dance. In this dance, performers (women and men) have to wear cultural attire made of reeds. In addition, there is some art deco attached to the attire, for instance, *Mpande*, *Simuma*, *Sihiho* etc. (shown in Figure 6.17).



Figure 6.17: An expert community member in the cultural attire

Explaining the attire, Onane Mukwangombe emphasised: “*Mpande kugava mfumwa zonene moomu gafumana hompa kadi goVaukwangali gedina Mpande*” [*Mpande* gives the proudness as that of the queen of the Vaukwangli community by the name ‘Mpande’]. *Sihiho* is the traditional ‘wig’ in the art deco style, while *Simuma* serves as a supplement to *Mpande*. When dancing *Epera* they have to stand in two lines, with women on one side and men on the other side facing each other.

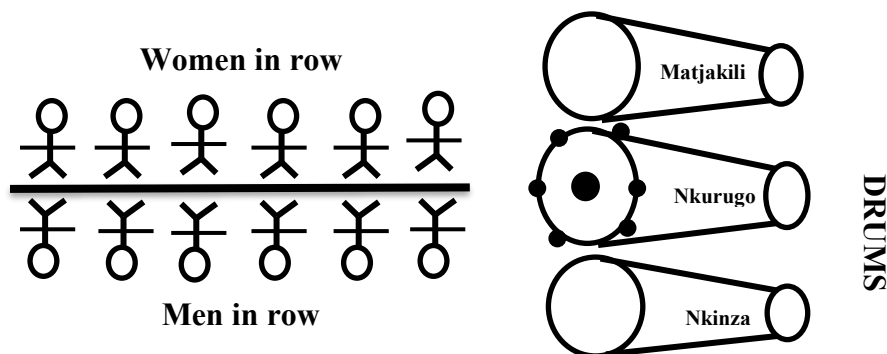


Figure 6.18: Represents dancers and combo of three drums played for the Epera dance
<https://r.search.yahoo.com>

During the dance, a man is the one who starts by coming out of the line to pick two women and then returns the two picked women to their place and then picks the other two women and passes them to another man, this goes on until the end of the dance. This dance is performed by moving the feet and shoulders when the dancing man raises their hands over the two selected women he is dancing with. Epera was a respected dance by the vaUkwangali community in the past. Usually, the dance was used to celebrate during harvests, weddings and other gatherings.

6.6 Data from the Grade 10 Physics Teachers During Drumming, Music and Dance

To ensure that the Physics teachers who participated in this study understood what they were required to do, the cultural practices related to sound were demonstrated and explained by the ECMs and each teacher was asked to reflect on their observations. In the demonstrations and explanations, community members revealed the rich Physics-related concepts (Ogunniyi, 2007a).

The use of a drum in demonstrating how sound is made exemplified the use of easily accessible materials (Asheela et al., 2021; Mavuru & Dudu, 2020; Shinana et al., 2021). In this case study, the views about Physics held by a group of Physics teachers whose teaching practice was traditional were brought to the community to observe how the cultural heritage might influence the teaching of science. It was revealed that *drum making, drumming, music and dance* taught the participants that indigenous materials like the trunk of the tree and raw animal skins have scientific value, in this case, in sound production.

Drums were mainly used to add flavour to the traditional songs and dances. In the demonstration and explanations, there were some concepts related to sound. For example, sound requires a medium to travel such as a solid, liquid or gas – this led to the teaching of states of matter and the kinetic theory of matter as emphasised by Blue et al. (2018).

Sound emitter: So, if a speaker, in this case, the drum's diaphragm oscillates back and forth more than about 20 000 times per second or so, we would not be able to hear such *sound* produced at high frequency.

Sound wave: Another key aspect of sound waves is the wavelength of the sound wave which is the distance between two compressed regions of the sound waves measured in metres – sound waves travel through the air.

The dance activity revealed that all the Physics teachers managed to make connections between the demonstrations and explanations of the targeted concepts. For example, a longitudinal wave moves in the same direction as wave travel (this is a good example of sound waves). The activity led the Physics teachers to imagine the following: amplitude; wavelength; crests and troughs as the tones of sound are altered by heating the skin, the type and thickness of the animal skin and the size of the hollow and its thickness. A goat's skin is thinner than that of a cow. A thick skin vibrates slower and has a lower tone than thin skin.



Figure 6.19: Heating skin to alter the tune of a drum through thermal radiation

In this way of warming skin over the drumhead, Otate Matia explained that it makes skin to stretch. In addition, this is the method of tuning the tone of the drum for drumming. Otate Matia commented that “*ngoma kuzireta pepi nomundiro, upyu taugendi uzi durure zahana kuguma komundiro*” [The drum is brought near the fire, so it is heated without contacting the fire].

Hence, the drum making activity led the Grade 10 Physics teachers to understand the following science concepts: amplitude; wavelength; crests and troughs as the tones of sound are altered by heating the skin. Similarly, the following Physics concepts were also reflected in *drum making, drumming, music and dance*: Tension and diameter versus frequency, pitch and tune of the amplitude, and the wavelength of the softness and loudness of a sound wave when drums are played.

In this regard, Mburu expressed that it seems like each drum has its own level of tuning by heating its skin to give a suitable sound to the audience. During the reflections, the Physics teachers expressed their views on the amplitude and the wavelength of the softness and loudness of a sound wave when drums are played. To these Physics teachers, there is no marked difference between the two, so they can be used in a complementary manner. This seems to describe an underlying equipollent worldview in the CAT classification as these excerpts show:

Loudness is the technique in which our ears perceive sound wave amplitude, and the larger the amplitude is, the louder the perceived sound. Amplitude is referring to the magnitude of the sound wave (Kaurungi).

The way that eardrums perceive a sound and once amplitude is increased, the sound gets louder, and when it is decreased, sound gets quieter, and wavelength becomes short (Lyako).

The loudness of a sound wave could be determined by the amplitude of the sound wave (Kambinda).

The outcome is that the longer the amplitude, the more energy in the wave, it influences the wavelength to become short (Nda-Kulanda).

The membrane makes teachers visualise the waves to be bigger and the distance between two crests became shorter when ... the drummer plays the drum (Kondjereni).

From these excerpts, these teachers explained the effects and relationship between amplitude and loudness. The level of identification of sound components displayed the ability of teachers to prepare concrete tasks that learners can perform.

Moreover, these Physics teachers were then able to identify and associate *sound* with key concepts, for example, reflection, energy and vibration. For instance, “*energy is the ability to do work so, you (dancers) are capable to hear sound waves for the reason that sound is travelling in the form of energy to their eardrum*” (Kaurungi).

This excerpt resonates well with scholars such as Seehawer and Breidlid (2021) who advocate dialogue between epistemologies as a method of knowledge integration that allows serious and constructive engagement with knowledge systems in the classroom.

During the stimulated recall interview, Kambinda expressed that:

When teachers bring real teaching media to class like in the case of the drum, it makes it easier for learners to connect theory with practice which ultimately results in them comprehending concepts better since they have been given a chance to involve all their senses in the learning processes – this promotes deeper internalisation of the concept and when it comes remembering it would not be difficult as their long-term memories are activated (SRI).

The excerpt demonstrates the role of easily accessible materials that are found in the environment we live in. This finding has an affinity to Asheela et al.'s (2021) assertion that science concepts can be taught using easily accessible resources. The community can be engaged in outsourcing knowledge relevant to the teaching of Physics. Mateus and Ngcoza (2019) emphasise that the community keeps their cultural heritage by implanting the valuable knowledge and skills in young people to ensure that it is passed on from generation to generation. The community uses the natural materials for an activity like making drums, drumming, music and dance and connects it to the concept of sound and how sound is produced. Participants were able to realise that knowledge is not only found in the physical classroom or with teachers only but also in the community, and knowledgeable persons, in this case, are the community members who know and have the skills to make the drums.

The Grade 10 Physics teachers discovered that these ECMs educate each other to prevent and eradicate bad quality skins – for drumheads and even for the baby carriers. These defaults can be limited by adopting standardised criteria for a thorough assessment of the quality of skins for sound production as determined by skin size. Teaching methods that fall into this category seem to emphasise guiding learners' work on the academic subject matter. During the stimulated recall interviews, Lyako reflected that:

If possible, the teachers should document everyday knowledge in a journal and then turn it into teaching material for the teacher to use in their classes. Curriculum developers should engage teachers and teacher educators to equip student teachers who will pass this knowledge to their learners and society at large.

This study is interesting in this context, emphasising the teacher's role in capturing learning in such settings and showing that prior everyday knowledge can be used as resources that upkeep deep intellectual engagement (Kuhlane, 2011). In addition, it creates a learning environment in which learners can *reason, reflect, and richly discuss the scientific matter*, in doing so, learners would be able to acknowledge the cultural ways of producing sound and the essence of cultural artefacts.

The study promotes a *sense of belonging* and *identity* which involves the feeling, belief and expectation that one fits into a group and has a place there, a feeling of acceptance by the group, and a willingness to benefit from the group. It is my group and *"I am part of the group"* (Hardy et

al., 2020, p. 12). One such directing concept is shared values. Our culture and our pedagogical content teach each of us a set of personal values, which indicate our emotional and intellectual needs. Below I present the topic of gender and the Unongo Youth Group.

6.7 Gender and Unongo Youth Cultural Group

In the social group of Unongo, gender plays an essential role to sustain the honour of the group irrespective of the position one holds in the civil society. It was revealed that gender equality is highly considered and intrinsically linked to sustainable development and is vital to the realisation of human rights for all. Similarly, this study of the cultural heritage of *drum making*, *drumming*, *music* and *dance* shows that an individual can no longer be understood without their cultural means; and that their society can no longer be understood without the agency of individuals who use and produce artefacts.

In each portfolio, gender is represented. For instance, if the chairperson is a male, then a female would be a deputy and the division of their labour is also equal during this intervention as stated by Engeström and Miettinen (1999) within the activity system. These community members had achieved gender equality as important for their group not only because it is “fair” and “the right thing to do”, but because it is also linked to the group’s overall performance and places the group on the map due to these good practices. The study found greater evidence that the community members are influenced by the gender norms of the group rather than their characteristics, particularly if they practice for any performance.

A culture of unremitting learning is integral to promoting the function of this community member, particularly the Unongo Youth Cultural Group. Moreover, all equipment used in their cultural concerts is made by group members from easily accessible materials as reiterated by Asheela et al. (2021). Next is the summary of the findings.

6.8 Summary of Findings

The data sets presented in this section were meant to answer the question of how teachers’ interactions and participation during the practical demonstrations and explanations were essential in understanding how to integrate IK when teaching concepts of sound and other associated concepts in Grade 10. The interaction of Grade 10 Physics teachers and ECMs lies in an active

will for the community (Mbembe, 2021). In this regard, Mbembe (2021, p. 3) states that “this *will* to the community is another name for what could be called the *will to live*” (emphasis original).

Data from participatory observations revealed that the participating Grade 10 Physics teachers had experienced and comprehended the science concepts embedded in the process of *drum making, drumming, music* and *dance* which subsequently contributed to their improved PCK (Mavhunga & Rollnick, 2013; Shulman, 1987). It also emerged that the cultural heritage of this community enabled the Grade 10 Physics teachers to understand other science concepts and most importantly, how IK could be integrated into science teaching. Moreover, the practical demonstrations and explanations of *drum making, drumming, music* and *dance* also became valuable in creating more culturally responsive pedagogies as reiterated by Mhakure and Otulaja (2017) and other proponents of IK.

This educational intervention helped the Grade 10 Physics teachers to become more engaged in the professional learning community. That helped them to connect their science learning to other subjects and strengthened their understanding of science. In this regard, Kambinda commented that this study has provided a double benefit:

These corporations provide teachers with more authentic ways to develop necessary knowledge and skills, aiming to engage learners in curricular topics that explicitly relate to where they live, and to use their community as a source and location for learning (SRI).

This extract resonates with Reichert et al. (2020) who emphasised that interactions, participation and teaching provided a way to engage teachers in authentic, relevant and meaningful teaching through learning activities nested or centred in their communities.

6.9 Chapter Summary

This chapter presented data on the Grade 10 Physics teachers’ interactions, participation and learning (or not) during the ECMs’ practical demonstrations and explanations on *drum making, drumming, music* and *dance*. The study further promoted a sense of belonging and identification (Stachl & Baranger, 2020), which includes the feeling, belief and expectation that one fits in the group. Chapter Six had the specific task of comprehending the place and role of cultural aspects in the lives of the Ukwangali community as represented by the Unongo Youth Cultural Group. In

addition, Grade 10 teachers realised that through *drum making, drumming, music* and *dance*, they learnt that sound travels in pattern waves and the vibration of the drum cone transfers the sound energy from the source to the receivers. The membrane thickness and tanning affect the sound phenomena such as high and low pitch and softness and loudness of the sound.

This chapter, thus, recommends that there is a need to empower science teachers on how to integrate IK into their science teaching to make science accessible and relevant to their learners' lived worlds (Gwekwerere, 2016). The level of identification of sound components displayed the ability of teachers to prepare a concrete task that learners can perform. Regarding Physics concepts, teachers were able to identify the concept of sound and associated concepts, for example, *reflection, energy* and *vibration*.

In a nutshell, the Grade 10 Physics teachers learnt that a drum skin is a membrane stretched over one of the open ends of the drum. The vibration of the head drum and/or the membrane compresses the air inside the shell. In the next chapter, I present and discuss the data on the Grade 10 Physics teachers integrating the cultural knowledge from the community members *on drum making, drumming, music* and *dance* when co-developing exemplar lessons.

CHAPTER SEVEN: CO-DEVELOPMENT OF EXEMPLAR LESSONS, DISCUSSIONS AND REFLECTIONS

Interactions facilitate experiential connections, making experiences more memorable and longer-lasting, and encourage task-related and social support for peers. (Taheri et al., 2021, p. 12)

7.1 Introduction

The epigraph above suggests that the experience that the Grade 10 Physics teachers acquired during the ECMs' demonstrations and explanations stimulated them in their co-development of exemplar lessons. In this chapter, I present, analyse, interpret and discuss data for research question 3 of this study after the Grade 10 Physics teachers were engaged in the ECMs' demonstrations and explanations. The research question is:

How do the Grade 10 Physics teachers integrate the cultural knowledge from the community members on drum making, drumming, music and dance when co-developing exemplar lesson plans?

To answer this research question, I planned workshops to co-develop exemplar lessons with the Grade 10 Physics teachers to integrate the cultural knowledge from the community members on *drum making, drumming, music and dance*. The workshops enabled the Grade 10 Physics teachers to share the knowledge acquired from the ECMs. To understand how the teachers integrated IK into their teaching, teachers were put into pairs during the co-development of exemplar lessons. They were given tasks to try out what they learnt from community members in their teaching. The Grade 10 Physics teachers were also allowed to use their field notes about *drum making, drumming, music and dance* and identify some indigenous practices to illustrate the content of science. In so doing, Grade 10 Physics teachers identified some possible indigenous Physics knowledge from the Ukwangali community and then identified the topics that they could integrate IK into when teaching them.

Hollbrook and Ronnikmae (2009) claim that enhancing scientific knowledge is dependent on the need to “develop collective interaction skills, personal development, and suitable communication approaches” (p. 286). The Grade 10 Physics teachers were subsequently encouraged to teach the exemplar lessons in their classrooms. That allowed for a richer observation experience as well as identification of trends in teacher thinking and collaboration as a way to integrate IK into science curricula.

7.2 Indigenous Knowledge and Physics from the Ukwangali Community

As I stated earlier, in this phase three of the study, participants were put into three pairs to co-plan exemplar lessons that were later implemented in their classrooms. Each pair was allowed to review what they experienced during the demonstrations and explanations by the ECMs on *drum making*, *drumming*, *music* and *dance* and link that to the teaching of the concept of sound. In this regard, the pair of Mburu and Lyato reflected that:

Our reflection on the use of drums to teach sound begins with the materials from which the drums are made. The drums are made from wood and skin which are solids. In science, it's stated that solids transmit sounds better than liquids and gases because of the arrangement of particles.

The hollow space inside the drum allows particles to vibrate when the skin is hit by the drum beater/player and sound is transmitted out through the opening behind the drum (Nda-Kulanda & Kambinda). The reflective feedback was vital to refresh and visualise the patterns that were observed by Grade 10 Physics teachers and broaden their thoughts when co-planning the exemplar lessons.

7.2.1 Data from teacher discussions and reflections

Essentially, in this section, I describe the data from the group discussion and reflections of the six research participants (Mburu, Lyako, Nda-Kulanda, Kambinda, Kondjereni and Kaurungi). Grade 10 Physics teachers revealed that interaction with the ECMs helped them feel better prepared to plan and teach Physics aided by the integration of IK. The intervention of *drum making*, *drumming*, *music* and *dance* enabled them to change their views and expand their identity as Physics teachers. This section focuses on the Grade 10 Physics teachers' learning conversations during their engagement with the task of co-developing exemplar lessons and their use of the indigenous

technologies related to drum making, drumming, music and dance. Participatory observations on drum making, drumming, music and dance tasks promoted meaningful discussion about teachers' IK integration ideas. The six participants in this study deemed it appropriate to come together after interacting with ECMs as a group in a professional learning community to reflect and view each other's lessons and to learn from each other (Ngcoza & Southwood, 2019). Presenting and discussing data from the group discussions and reflections of the six teachers are discussed in detail in this chapter. I thus give narratives of how these teachers reflected on how the interactions with the ECMs benefitted their co-development of exemplar lessons which were done in pairs. Below I present the data revealed from Grade 10 Physics teachers' discussions.

Grade 10 Physics teachers' discussions and reflections: Social constructivism is used in this study as a referent to analyse and interpret relevant data presented in the chapter and particularly for this section. The core view of constructivist learning suggests that these teachers construct (rather than acquire) their knowledge, strongly influenced by what they already know (Walan, 2020). Consequently, the Grade 10 Physics teachers are thought to learn science through a process of constructing, interpreting and modifying their representations of reality based on their experiences demonstrated in the co-developed exemplar lessons. Social interactions construct knowledge whereby Physics teachers make meaning of the IK integration through the social processes (van Breda, 2018) of co-constructing and negotiating ideas through meaningful peer discussions. According to the participants, the discussions and the reflections were going to assist them in understanding the integration of IK during the co-developed exemplar lessons and learning how other pairs developed their exemplar lessons that involved IK (Meskill & Oliveira, 2019).

In the light of these reflections, I refer to it as reflective learning that resonates with Alsina and Mulà (2019) who state that reflective learning promotes the integration of people with their experiences as learners, theoretical knowledge and their representations of what it is to teach and learn. Equally, Yuan and Mak (2018) describe reflective learning as a method in which teachers are allowed to learn from their interactions, teaching experiences and the experiences of others. Similarly, Ngcoza and Southwood (2019) and Nhase (2019) refer to this as a professional learning community and even call it a professional learning network. This pair of Grade 10 Physics teachers, Mburu and Lyako related thunder, lighting and tracing shadow activity as mediating

cultural tools for the concept of light in the Grade 10 Physics topic. Below I present what Mburu and Lyako said about the identified cultural knowledge that would be suitable when teaching the concept of light and its properties. The application of that cultural knowledge was witnessed during the lesson observation in Chapter Eight.

Thunder and Lighting: The two Grade 10 Physics teachers referred to thunder and lightning as the easiest example to use when teaching the properties of light and sound respectively. They thus reflected that:

Thunder is the sound that happens after a strike of lightning during an electrical storm. During a thunderstorm, people see flashing first and hear sound later. This would motivate the explanation to say light travels in straight lines and travels faster in a vacuum than sound.

This excerpt resonates with Colomer et al. (2020) who state that reflective learning through a series of integrated and interactive tasks, for instance, collaborative lesson planning, group consultation, microteaching and videoed reflections, aids teachers in identifying an effective pedagogical approach from their experiences. It was expressed with the reason that light is an electromagnetic wave of a particular wavelength is that it is visible to the human eye. Normally, if we observe a person cutting a tree, first we can see an axe moving away from the tree trunk before hearing the sound (Mburu & Lyako). Below is one of the activities identified by Mburu and Lyako during the co-development of the exemplar lesson workshop of phase three of this study while others are discussed during the class observation.

Tracing shadow activity: In the Grade 10 Physics curriculum, there is a unit on shadows and light. So, a teacher may use shadow activities to show learners how light moves and shadows form and change throughout the day. They expressed that:

Shadow drawing can be done both indoors, with artificial light using a torch, and/or outdoors in the sunlight. The focal way to create shadow art is by tracing or drawing shadows to create shadow art. This could be done in a Grade 10 Physics class for such learners to realise that light travels in a straight line. The plan was to go outside and look for shadows with learners.

In the extract above, these Physics teachers considered using the Inquiry Cycle-Engage, Explore, and Reflect approach which resonates well with Spencer and Guillaumes' (2006) study to organise the teaching approaches. They prepared to allow learners to explore shadows both inside and outside, and then reflect on what learners had learnt from the two sets of experiences as an indication that science and IK integration needs to be taken more seriously in Namibia.

This activity has the potential to help Grade 10 Physics teachers understand that the learners have some prior knowledge (Mavhunga & Rollnick, 2013) about shadows and their formation as well as the behaviour of light when opaque materials are struck as stated in Winne's (2021) study, that what learners know significantly shapes what they learn. The detailed lesson on shadow art is presented in Chapter Eight of this thesis. Below I present the type of textbooks Grade 10 Physics teachers used when they co-developed exemplar lessons on the integration of IK.

7.2.2 Grade 10 Physics textbooks

A textbook is a book containing a comprehensive gathering of content in a branch of study to explain it (Simu, 2019). Textbooks are produced to meet the needs of teachers, usually at educational institutions. In this phase three of this study, the Grade 10 Physics teachers mostly used three textbooks for Grades 10–11 respectively. These three textbooks were:

- Living Physics Learner's Book 10 & 11;
- Namibian College of Open Learning (NAMCOL) Ordinal Level 10-11 Physics Learner's book new curriculum; and
- Solid Foundations Physics Grade 10 and 11 Learner's Book.

During this stage, Mburu and Lyako were able to strengthen and validate concepts in the textbooks and cultural heritage of *drum making*, *drumming*, *music* and *dance*. For instance, when the community members were beating²³ the drum to vary the tune, Mburu and Lyako learnt that this

²³ Beating the drumhead enables the skin to stretch to create some tension that generates a particular type of sound (Liveve, 2017). Equally, tension refers to how tightly the skin is stretched as explained by the drum maker – Otate Matia.

demonstration was the steppingstone for collecting materials found in the community with different properties such as transparent, opaque and translucent when teaching light and shadows.

7.2.3 Field notes

During or after their observations of the demonstrations and explanations by ECMs, the Grade 10 Physics teachers were able to align cultural technologies in the teaching of science concepts. They also realised that community members have rich knowledge of the concept of sound and other related Physics topics. The total nature of science is reflected in the tonal capabilities of the musical instrument as well as their tuning practices. This is the reason why in this study, I did not only explore the mobilisation of the indigenous technology of *drum making, drumming, music and dance* for cultural revitalisation but to contextualise Grade 10 Physics lessons on the topic of sound.

Teachers used more elaborate materials or adapted the materials to make them more challenging such as *drumming, lightning, thunderstorm and tracing shadow activities* in a way to include more scientific content. In the co-developed exemplar lesson workshop, the Grade 10 Physics teachers made an effort to bridge the science content and skills-based society (MEAC, 2010).

7.2.4 Past examination papers for Grade 10 Physical Science

In this section, I use the term Physical science simply because these past exam papers were set up before the curriculum was split into Physics and Chemistry. The Grade 10 Physics teachers used these to analyse how examiners accommodate IK in the examination papers. They identified the benefits of studying exam papers before examining the concepts that appeared in these past exam papers and the IK reflected. The aim associated with the use of past exam papers included the following:

- *Aids understanding of likely exam time length;*
- *Specifies the typical number of questions;*
- *Pinpoints number of choices provided;*
- *Helps work out the time required for each question;*
- *Classifies style of exam questions (short-answer, multiple-choice or practical);*
- *Helps practice exam techniques; and*

- *Helps identify key subject areas to focus on in revision (Kaurungi & Kondjereni).*

Moreover, the most significant benefit of the past papers is that they help both teachers and learners understand the most likely topics to be included in the exams (Appendix V).

The reflections and discussions of each pair of the Grade 10 Physics teachers revealed that it is crucial to equip teachers with the necessary skills and knowledge on how they could integrate IK when teaching Physics concepts. It would help them develop cultural knowledge and connect it to their classroom practices and curriculum decisions as demonstrated in the *drum making, drumming, music and dance* explanations, and demonstrations done by ECMs in phase two of this study. This way, learning could become more meaningful – engaged teaching helps teachers understand how culture influences learning science as the examiners include some sorts of IK in examinations.

Discussions and reflections assisted each participant’s interpretations of the topic and gave hints about the uses of IK in science teaching. Moreover, demonstrations and explanations by ECMs enabled the Physics teachers to smooth the co-development of exemplar lessons. In this regard, Mburu and Lyako reflected that:

Teachers may understand what it means, it is very possible. In our case, ‘we always bring any knowledge from the local environment’. Teaching should integrate with learners’ experiences be it from the previous school, in the classroom or from home.

The excerpt above sheds light on the home and school experiences of a fast-growing tactic in learning science (Covarrubias et al., 2019). Below I present and discuss data that emerged from the co-developed exemplar lesson two.

7.3 Data that Emerged from Mburu and Lyako During the Co-developed Exemplar Lesson One

As I said in Section 7.2.1, six Grade 10 Physics teachers worked in pairs to co-develop exemplar lessons. Each pair developed two lessons. In each pair, teachers used the given materials as listed in Section 7.2.1 when co-developing lessons for the transfer of thermal energy for the topic of convections. The discussions and reflections for this pair of Grade 10 teachers revealed that teachers had an opportunity to develop a lesson on the concept of convection and were able to

identify indigenous practices associated with convection. Three Grade 10 and 11 Physics textbooks were used during the co-development of the exemplar lesson workshop. This pair of Grade 10 Physics teachers, in their discussion and reflections, revealed that the cultural practices such as sitting around the fire, ironing and a pot on a hot burner reflected the practical examples of convection (see Section 8.10). Fundamentally, the pair had written the following: *Convection*- “Is the transfer of heat through an object by the movement of its particles or by the changing of position of its particles” (Jeoffreys, 2018, p. 270).

In the everyday applications of convection current, the heating element of a kettle for example is always at the bottom, since hot water rises when water above the heating element is heated. Convection current also plays a significant role in our weather systems. For instance, river breezes are examples of convection currents along the bank that are often caused by the heat of the sun. Moreover, when two fluids (liquids of different densities) are placed in one container, the medium with a lower density rises above the medium with a higher density.

Adedirin et al. (2018) point out that although liquids and gases are poor thermal conductors, they can move and carry heat with them. Convection is the “process in which liquid or gas moves from a region of high density to a region of low density because of a temperature difference” (p. 167). Mburu and Lyako identified numerous examples of convection in everyday life, comprising several common household occurrences:

- Ice melting – Ice melts because heat moves to the ice from the air. As a result, the ice melts from a solid to a liquid by latent heat.
- Boiling water – When water boils, and the heat passes from the burner into the pot, heating the water at the bottom. This hot water rises, and cooler water moves down to replace it, creating a circular motion.
- Radiator – A radiator puts warm air out at the top and pulls in cooler air at the bottom.
- A steaming cup of hot tea – The steam one sees when drinking a cup of hot tea shows that heat is being transferred into the air.

Convection in simple words is the round motion that happens once warmer air or liquid that has faster-moving molecules, making it less dense rises, while the cooler air or liquid drops down (Mburu & Lyako).

7.4 Data that Emerged from Mburu and Lyako During the Co-Developed Exemplar Lesson Two

The main purpose of this pair of teacher’s discussions and reflections was to develop a lesson that could feature IK when teaching the topic of refraction and form of energy and be validated in Chapter Eight during class observations.

Mburu and Lyako co-developed two exemplar lessons – one of them on the properties of light in the topic of refraction of light, while the other was on the topic of the form of energy: kinetic and gravitational potential energy. During the co-development of the exemplar lessons, Kondjereni and Kaurungi selected the uses of refraction in our daily life (Gwekwerere, 2016). Their discussions revealed that refraction has a lot of applications in optics and technology. Among the few were that *“the refraction phenomenon is regularly linked with light, but can also be applied to other waves like sound or water”* (Kondjereni & Kaurungi).

In addition, a prism also uses refraction to form a spectrum of colours. Before I present some common explanations from the three Grade 10 textbooks, Kondjereni and Kaurungi identified numerous applications of refraction in everyday life during the co-developed exemplar lessons explicitly: a prism-rainbow; the formation of mirages; fishing; and a bent splint in a glass of water.

Adedirin et al. (2018) explained that refraction is “caused by the bending effect of light” (p. 203). It occurs when the light goes from one medium to another. The bending happens because light travels at different speeds in the medium with different visual densities. A prism uses refraction to make a spectrum of colours from an incoming beam of light. Moreover, a prism is an object made up of a transparent material, like glass or plastic, which has at least two flat surfaces that form an acute angle. White light is comprised of all the colours of the rainbow as shown in Figure 7.1 below.



Figure 7.1: Shows the dispersal of white light to form all the colours of the rainbow
(<https://images.app.goo.gl/jSzXWEJxYCxB1fwPA>)

The white light is the incoming ray (incident ray) and once it enters the glass prism the ray is bent to form a refracted ray. Then, when it leaves the transparent object, it creates an emergent ray that is comprised of all the colours of the rainbow as shown in Figure 7.2. Moreover, the refraction of light can result in the converging of diverging beams as discussed in Chapter Eight.

Primarily, a rainbow is a phenomenon caused mainly by *reflection*, *refraction* and *dispersion* of light in water droplets causing a spectrum of light to appear in the sky as shown in Figure 7.2. The Grade 10 Physics learners would make sense of concepts on refraction of light by exploring their everyday experiences about the rainbow (Homateni, 2012). Kondjereni and Kaurungi revealed that the use of Grade 10 Physics learners' cultural experience of the rainbow-*Ekongoro* could be useful in enhancing learners' engagement, meaning-making and conceptual realisations when teaching the concept of refraction.



Figure 7.2: A rainbow appears in the sky when sunlight hits water droplets

Kaurungi expressed that:

When rainbows appear in the sky, to the vaUkwangali community it means more than refraction of light in the classroom. So, the rainbow in their context is perceived as a snake that lives in both water and on land. Rainbows can suck blood from people and animals or swallow them. By myths, the thunderstorm we hear is a result of fighting between the rainbow and God during rainfall (Kaurungi).

The extract above reverberates well with Ogunniyi's (2007a) CAT, which explains that these teachers seem to be having dominant IK, with scientific worldviews being suppressed or assimilated.

7.5 Data that Emerged from Kondjereni and Kaurungi During the Co-Developed Exemplar Lesson Two

The co-developed exemplar lesson was done to consolidate the ideas of two Grade 10 Physics teachers during this phase of the study. Kondjereni and Kaurungi were able to co-plan an exemplar lesson on forms of energy: kinetic energy and gravitational potential energy in a class for Grade 10. Hence, a teacher can use the practice of traditional threshing as energy converted from a person as stored chemical energy to kinetic energy, gravitational potential energy and sound energy when

the sticks hit the millet-sorghum grains (Chemical energy → kinetic energy → gravitational potential energy → kinetic energy → sound energy).

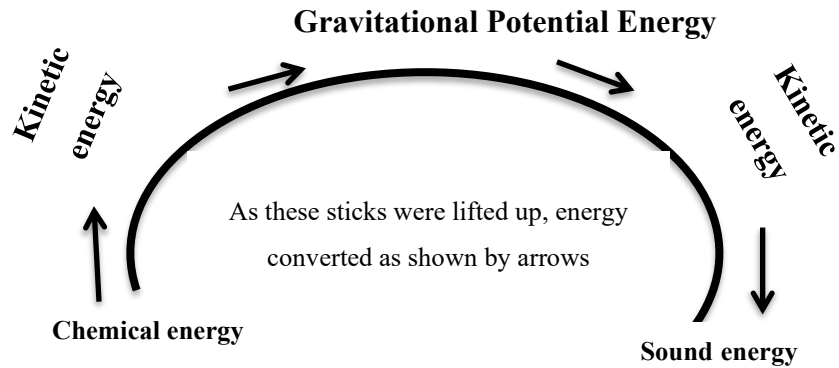


Figure 7.3 & 7.4: Shows energy conversion when threshing and the threshing in practice

These teachers revealed some explanations from the three Physics textbooks that were supported by this community knowledge. For instance, in the Physics Grade 10 and 11 learners’ books for NSSCO, they state that the form of energy particularly kinetic energy and potential energy are explained differently. Kinetic energy is the form of energy of a body in motion, while potential energy is stored energy that entails numerous forms of potential energy, for example:

- Strain potential energy is the energy of “an object when it is stretched, compressed, or deformed” (Barrett et al., 2018, p. 179).

- Gravitational potential energy is the energy of a body because of its position relative to the ground.

Kondjereni and Kaurungi analysed the past examination papers as indicated in Figure 7.5 in this chapter. In this regard, lowering a bucket in a well to draw water is a very practical example when mediating the concept of kinetic and/or potential energy in a Grade 10 class as shown in Figure 7.5 below.



Figure 7.5: Indigenous technology for drawing water from well to mediate learning of the concepts of kinetic and gravitational potential energy

In this regard, Jeffreys (2018) explains that although there are many different types of energy, there are only two main forms of energy. These are kinetic or movement energy and potential or stored energy, therefore, kinetic energy involves travelling from one area to another. Gravitational potential energy is referred to as “energy stored in objects higher than ground level, such as water stored behind a dam” (p. 204). To this point, Adedirin et al. (2018) state that kinetic energy is the energy an object has due to its motion. As soon as an object starts moving, it has kinetic energy. The amount of kinetic energy an object has depends on two factors: the mass of the object and the speed at which the object is travelling. The activity of a slingshot-*ngumi* is explained in Chapter Eight during classroom observations. Below I present the data from co-developed exemplar lessons for Kondjereni and Kaurungi in this phase.

7.6 Data that Emerged from Nda-Kulanda and Kambinda During the Co-Developed Exemplar Lesson One

At this point, this pair used the knowledge and skills acquired from ECMs when they were demonstrating and explaining *drum making, drumming, music and dance* when teaching sound waves and their phenomenon. Their data from past exam papers are consolidated in Appendix V.

Nda-Kulanda and Kambinda revealed that all the site visits in phase two for participatory observation enabled them to identify IK for the workshop for co-developing exemplar lessons in phase three. Nda-Kulanda explained that:

Drumming shows a phenomenon reliably reproduced so that learners could learn first-hand from the phenomenon instead of it being described to them, and possibly, their trying to visualise it. Subsequently, the phenomenon is not easy to reproduce; the successful outcome of indigenous knowledge is evidence that they are vehicles when learners carried out Physics activities – and with sufficient care and skill from the community members, learners can learn new ideas by showing examples of them, rather than being given formal definitions or other verbal accounts.

The demonstrations and explanations of *drum making, drumming, music and dance* by ECMs constructed knowledge for Grade 10 Physics teachers to plan lessons and explain that sound travels from the source to the listeners by vibrations. The discussions and reflections enabled teachers to handle the delivery of their lessons during classroom observations. In this regard, Lyako explained that “*banging a drum makes the tight skin of the drum vibrate at a very high speed, forcing the air around it to vibrate as well*” (SSI).

Through singing and ululating, people generate sound with a high frequency and high pitch. This pair emphasised that the females’ voices during the dance had a high frequency and high pitch while males’ voices generally had a lower frequency and lower pitch. In the discussions of Kondjereni and Kaurungi, it emerged that “*sound waves carry sound energy through a medium such as air. This made participating Grade 10 Physics teachers and community members hear the sound as its sound travels from the drum to their ears*”.

As the skin vibrates uninterrupted, a continuous wave of a compressed and expanded section forms in the air. Sound waves are produced when “vibrating material causes particles to oscillate along the same line as the waves travel, creating areas of high and low pressure” (Jeoffreys, 2018, p. 343).

7.7 Data that Emerged from Nda-Kulanda and Kambinda During the Co-Developed Exemplar Lesson Two

These Grade 10 Physics teachers managed to plan an exemplar lesson on the reflection of sound to integrate IK when teaching the concept of echoes. Based on the co-developed exemplar lesson, it was revealed that past exam papers and the examiners’ reports during document analysis indicated the misconceptions about the role of echoes to humans and animals and why sound waves reflect. The pair explained how to help learners to understand the reasons why and how sound is reflected and the essential role of echoes to humans and animals. To this point, in the co-developed exemplar lesson on reflection of sound – echoes, teachers were asked to re-watch some of the movies in the video clips to emphasise specific Physics concepts of an echo. The video recording was done earlier in phase two during the demonstrations and explanations of *drum making, drumming, music and dance* by community members. The pair, Nda-Kulanda and Kambinda revealed that “*involving indigenous music and dances to teach a reflection of sound, emphasises the importance of identifying traditional cultural activities for their possible value to the curriculum*”.

The performance and explanations from community members enabled the Grade 10 Physics teachers to arrive at a point of developing exemplar lessons with confidence to explain to the learners when teaching the reflection of sound. Barrett et al. (2018) refer to an echo as the second sound that you can hear after you have made a noise. For instance, if you stand at a distance from a wall and clap your hands, you would hear a second clap shortly after you have clapped. Sound also travels in a straight line, particularly in the air. When “the wave hits a flat wall perpendicular to the source of the sound, some of it is reflected” (Adedirin et al., 2018, p. 224). In this workshop, the echo activity was specifically prepared to aid the conceptual development of Grade 10 Physics learners as indicated below:

Echo activities:

Activity 1: With the help of a teacher, find a spot outside that produces an echo when you speak or make a noise. As learners produce an echo, learners discuss the path of sound waves from their mouth back to their ears as the echo is made. The teacher is sure to talk about reverberations.

Activity 2: Instruction: Draw a diagram that shows what happens as echoes are made. Begin with a person making a noise on the left side of the page and a wall to create reverberations on the right side of the page. Then, draw in the path that sound waves take to form the echo.

This pair gave assurances that their teaching of these echo activities and a well-known folktale would enable learners to realise that an echo is when sound is sent back to the source's ears. Now I present the summary of the findings.

7.8 Summary of Findings

In this section, I summarised how the Grade 10 Physics teachers integrated the cultural knowledge from the community members on *drum making, drumming, music and dance* when co-developing exemplar lessons. Moreover, as a result of Grade 10 Physics teachers being exposed to the indigenous technology of *drum making, drumming, music and dance*, they were able to identify the topics in which they could integrate IK when teaching them.

This study reveals that the teachers were empowered to explore how to integrate other IK when teaching other science concepts in addition to sound. For instance, Appendix N shows the responses from participants when doing reflections in their discussions. To strengthen the dialogues on data analysis and presentation of what came from the participants about teaching science through culturally responsive pedagogies (Mhakure & Otulaja, 2017), I used the cognitive states of Ogunniyi's (2007a) CAT (see Appendix N) and DAIM. Teachers were asked to identify local technologies and then explain the science involved in them. All six participants expressed their understanding of indigenous technologies and related them to their school science. Nda-Kulanda further narrated that teacher use rulers to demonstrate sound production and yet "*in our culture, 'vaUkwangali' is rich with musical instruments using a bin drum; every year we are*

having a cultural competition by hitting a drum, and the skin vibrates. Community or learners know how to make and play drums”.

This excerpt illustrates that drumming is an example of indigenous technology in the community which is the major source of rhythm and music. Kambinda further explained that most of his learners are from *Vakwangali* native or cultural backgrounds. Mburu did not see the relevance of integrating science with IK because they thought that IK was old-fashioned or useless in the science class (Horsthemke & Schafer, 2007).

In terms of Ogunniyi’s (2007a) CAT, it could be imagined that these teachers seem to have dominant scientific worldviews, with IK being suppressed or assimilated as further evidenced by these statements. *Lyako explained that “current classrooms don’t need old things in it” and Kaurungi expressed that “it has somehow come to a thing of the past”.* Kondjereni also felt that *“it does not help with calculations”.* Similarly, there are some cultural practices noted by the participating teachers and suggested concepts involved as shown in Appendix O. To support what the participating teachers had pointed out and also for further use, I took some pictures which could be used by science teachers in the teaching and learning of science. In this regard, Mburu mentioned the following examples of IK:

Teaching mechanics, I normally talk about fetching water from a well (Ndjombo), because most of my learners come from inland (villages) where there is a rare amount of water. People have to dig water from the ground, so, they normally use a bucket tied on two poles with rope and lower it in a deep hole to collect water. So that one is like a pulling system to make work easier. They do that at home, and they realised that it is not strange.

Similarly, Lyako expressed that tanning is done perfectly when wood ash is poured over the skin and then soaked for two to four days. This allows the skin to loosen far easier. In this regard, Lyako commented that:

Another example is for teaching pendulums in Grade 12 when teaching time. One can use the practice called churning (Kusika masini), shaking fermented milk in the calabash done by one or two people facing one another. Learners will first learn through the practices they do every day at home at least that part of the learning they will possess, since it is found almost in every house that has a kraal. Often done during rainy seasons when cattle have enough for grazing.

From these excerpts, it could be construed that through a constructivist approach, instructional theories focus on real-life activities as a means of motivating science learners. Context is an important factor that affects learning performance and also enhances learner interest and efficiency. Equally, Huang and Liaw (2018) state that learners actively interact with the real world, applying their knowledge to daily life activities, thus increasing the effectiveness of learning outcomes. Figure 7.6 below shows the indigenous technology which could be used when teaching the topic of pendulums. In the same vein, Kaurungi expressed that in both Kavango West and East as well as the four northern regions, man is responsible for churning the milk. Moreover, she affirmed that our learners have opportunities when learning about pendulums since most of them have access to this practice of churning.



Figure 7.6: Calabash-*Hupa* for churning fermented milk

During interview analysis, Kondjereni and Lyako reported that some cultural technologies would expose science (also shown in Figures 7.5, 7.6 and 7.7). This finding has an affinity to an equipollent mental state where two competing ideas exert comparably equal intellectual force on a person (Ogunniyi, 2007a). In this case, the ideas tend to co-exist as would be the case when a

Grade 10 Physics teachers accept as equally valid two conflicting worldviews. For instance, Figure 7.5 shows that a rope is used in suspending the calabash with fermented milk – this seems to describe a causal equipollent worldview according to the CAT, while a horizontal wooden pole is used as a pulley that makes work easier. So, the horizontal wood acts as the lever, the rope around it acts as the pulley and the calabash is the load.

This cultural artefact of Figures 7.5 and 7.6 enabled Physics teachers to mediate learning of the concepts of mechanics when teaching about the pulley system. The indigenous technology below in Figure 7.7 was revealed during the Physics teachers' dialogues. For instance, Kanbinda reported that traditional thrashing-*Kupuma* could be integrated into the teaching of separation of substances as well as energy conversation as explained below.



Figure 7.7: Community members at Sapira farm thrashing-*Kupuma* sorghum where energy is converted

Regarding Figure 7.7 above, Kaurungi explained that before the sorghum grains were ready (Figure 7.8) it was not possible to separate them from their stalks as shown in Figure 7.7. She further expressed that the traditional thrashing could be used to mediate the topic of energy conversation. For instance, as these sticks were lifted, they all possess gravitational potential energy. Such traditional thrashing enabled teachers to mediate learning of the concept of sorting in the topic of separating mixtures.



Figure 7.8: Sorghum grains are ready to be separated from their stalks by Onane Makena goMukwanzadi

In Figure 7.8 above, the woman is removing the stalks from the millet after which the sorghum grains are ready to be kept in a silo-*Kahanda*. In this regard, it was suggested that learners could master the concepts of energy conservation as well as separating mixtures.

Reflections revealed that a teacher can use it when teaching materials, while Figure 7.6 could be suitable for mediating the concept of the pendulum (Nda-Kulanda). Furthermore, Kaurungi explained that the point of sitting around the fire could help teachers explain the term of convection. In Physics, convection is like an invisible conveyor belt that can transfer heat through

fluids (liquids and gases). Burning wood is a chemical reaction where wood is chemically combined with oxygen to form coal, carbon dioxide and energy as new products.



Figure 7.9: Members sitting around the fire and telling stories

Figure 7.9 shows ECMs telling stories while the entire family sits around the fire which is important because it would make information more personal (Mocnik & Fairbairn, 2018). In addition, Mburu explained that an arrow and bow can be used when teaching the concepts of pressure, motion and energy conversion (see Figure 7.10 below).



Figure 7.10: Arrow and bow are aimed at the target by the hunter

Arrow shafts can be made of sticks from a berry shrub called *Grewia retinervis-Simaka*, one of the toughest and most durable shrubs, while the arrowheads or a point are made of metal and come in various shapes and sizes. The smaller the size of the arrowhead the greater the pressure to pull the arrow into a position which causes the bow to have potential energy. Fletching²⁴ creates wind drag and can also cause the arrow to spin similar to a rifle bullet, providing stability and accuracy in flight.

The workshops also revealed that the Grade 10 Physics teachers seemed to embrace the idea of integrating science and IK into science teaching. Thus, integrating science and IK would broaden the knowledge base from the narrow focus of school science. The Physics teachers tried to include indigenous practices in discussing their science lessons to arouse the interest of their learners. Appendix W shows the summary of the topics the participating Grade 10 Physics teachers prepared during the co-developed exemplar lessons workshop.

In these workshops, linking concepts that are relevant to learners' everyday life helped the Grade 10 Physics teachers to make meaning as described in Samad et al.'s (2021) study, that information becomes more meaningful and directed if it is integrated into the daily life and experience of children. In this regard, these teachers explained that their experience with ECMs influenced their understanding of science concepts involved in cultural heritage and the ways of integrating them into the school curriculum.

7.9 Chapter Summary

This chapter presented data for research question 3 of this study after the Grade 10 Physics teachers were engaged with the ECMs' demonstrations and explanations. Similarly, the Grade 10 Physics teachers were able to share their experiences acquired from the ECMs during demonstrations and explanations of *drum making, drumming, music* and *dance*. Also, the practical demonstrations and

²⁴ It is the fin-shaped aerodynamic device attached to the shaft of arrows, providing an arrow with feathers for flight. Cultural community members use light objects like feathers.

explanations enabled them to co-develop exemplar lessons such as the properties of sound – loudness, high and low pitch, amplitude and frequency.

The refraction of the light lesson was linked with the cultural belief in the rainbow. The shadow that ECMs used to estimate time was integrated into the topic of the basic concepts of light – transparent, translucent, and opaque materials. Most of the cultural technologies reflected in the past exam papers revealed that it is very essential for both teachers and learners to study the past exam papers since they will help them to understand the most expected topics that are included in the examinations. In doing so, the Grade 10 Physics teachers demonstrated that they had learnt some of the IK which could be integrated into their science teaching. In the next chapter, I present and discuss the data that emerged from lesson observations that integrated indigenous technologies when Grade 10 Physics teachers enacted their co-developed exemplar lessons in their classrooms.

CHAPTER EIGHT: INTEGRATION OF INDIGENOUS KNOWLEDGE IN THE OBSERVED LESSONS

The consideration to integrate the indigenous perspective will facilitate the reconceptualization of the subject and its teaching. Indigenous learners cannot afford not to be taught the technologies existent in their communities. (Gumbo, 2020, p.4)

8.1 Introduction

In this chapter, I present data for research question 4 of this study which is:

How do Grade 10 Physics teachers mediate learning during enactment of the planned exemplar lessons in their classrooms?

For this research question, I focused on understanding how the Physics teachers mediated learning of the lessons that they co-developed. As the Grade 10 Physics teachers co-developed the exemplar lessons, they were expected to use what they had learnt about sound-related concepts linked to *drum making, drumming, music and dance* during the demonstrations and explanations by the ECMs. In this regard, *the drum making, drumming, music and dance* interventions were used as cultural tools to enable the Physics teachers to identify other suitable indigenous technologies to be integrated into their science teaching.

The data presented were generated from three research participants, namely Kaurungi, Lyako and Mburu. Before the presentation and discussion of data, this chapter firstly begins by giving a table of the observed lessons from all three teachers, a classroom context of each teacher as well as brief descriptions of the six observed lessons from the three Physics teachers in this phase of the study. To make meaning of the data, I used the following codes for presenting and discussions in this chapter. The lessons observed were coded as observed lesson 1 (OL1) and observed lesson 2 (OL2) for every cycle.

Table 8.1: Observed lessons from the three Grade 10 Physics teachers who participated in this phase for cycles one and two (Kaurungi, Lyako & Mburu)

Physics Teacher	Observed Lessons (OL)		Gender
	1	2	
Kaurungi	Transfer of thermal energy: Convection	Refraction of light	Female
Lyako	Conservation of energy: Form of energy (kinetic and potential energy)	The basic concept of light: Shadow	Male
Mburu	General properties of sound waves: Longitudinal waves and transverse waves	Reflection of sound: Echo	Male

These lessons were conducted each for 40 minutes as per curriculum directives. The school and the classroom contexts were arranged as per COVID-19 regulations, for example, the number of learners in the classroom should not exceed 20 so that there is social distancing, and the wearing of masks and sanitising which were adhered to.

8.2 The School and Classroom Context

In this section, I present a brief background of the three schools where the three teachers taught. A detailed description of every classroom is discussed below.

8.2.1 Kaurungi

Kaurungi is a female Grade 10 Physics teacher at a township school consisting of 1 318 learners (633 boys and 685 girls), and 41 teachers with two school administrators and two institution workers from Grade 4 up to Grade 11 respectively. The school is a cluster centre and gets funding from parents voluntarily and mainly from the regional council via the Directorate of Education, Arts and Culture using Educational Grant. The same Directorate of Education, Arts, and Culture aids the school with the school feeding programme that helps encourage learners from poor backgrounds to attend their classes. Parents come to school at a regular time to prepare the soft porridge for learners of this school from Monday to Friday.

The Grade 10 Physics class for this study consisted of 11 learners (four females and seven males). The space of this classroom allowed the teacher to move around freely to maintain order and discipline. The noticeboard and green/blackboard were mounted on the wall. It had sufficient ventilation and windows were taken care of and all rubbish was kept in a trash bin for disposal. The timetable was displayed on the noticeboard to assist learners to know which teacher was next for a specific subject on that particular day.

Lastly, the desks were arranged for learners to sit in groups of four. There were two groups with four learners, while one group consisted of three learners only. This teacher had been teaching Grade 10 for three years, and she loves interacting with her learners. As one of the three Physics teachers observed, her years of teaching experience made her the least experienced teacher. She revealed that:

I studied Mathematics and Science Upper Primary at UNAM²⁵, Rundu campus. I was appointed to teach Physics Grade 10–11. Throughout my teaching, I have experienced that the Physics Grade 10–11 syllabus has a lot of content. Also, I have been struggling to link most of my lessons with indigenous knowledge. However, since, I took part as a

²⁵ University of Namibia

participant in this study, I am now able to relate most of my Physics lessons to indigenous knowledge/ early life situations (Kaurungi).

According to her, she takes her teaching obligations seriously and is committed to transforming what she has and knows for these Namibian learners of this township school. In this study, her lessons involved the indigenous technology of sitting around the fire when telling stories about jackals and hyenas while sharing an equal amount of heat radiated from the fire as energy is transferred (Transfer of thermal energy: Convection) and in the bow fishing arrow (Refraction of light) as indicated in Figure 8.5.

8.2.2 Lyato

This is a male teacher who expressed that teaching Physical science has been an interesting journey. He had been teaching at different levels and learnt different understandings of how learners from different schools understood the different topics. He felt that it was not a difficult subject but many view it as an abstract subject. Moreover, Lyato said:

I have been teaching Physical science because in the previous curriculum it was Physical science up to Grade 10. I have been teaching that in Physical science they are topics for chemistry and Physics yes it was a great journey. But, still, some learners at some schools find it easier and others still struggle with the subject content.

Importantly, the year 2020 was the first time that the Grade 10 learners did Physics and Chemistry separately which were the phases that he was not teaching. This teacher teaches at a school that has experienced a lot of challenges such as teaching aids and learners not wearing school uniforms. The school does not have a science laboratory and the funds that the school receives from the Directorate of Education Art and Culture are not sufficient to fully support teaching and learning.

Although the school has had challenges, it always promotes discipline and respect, both among teachers and learners. This respect is also extended to the community around the school. That was demonstrated through voluntary participation by the community in the school feeding programme. The participant's classroom was arranged in a manner that promoted group work (while they were wearing their face masks) and engagement between learners which promoted learning through social interactions as indicated below in Figures 8.1A & B).



Figure 8.1: Lyato's classroom arrangement

Lyato's class consisted of 15 learners (seven girls and eight boys). In Figure 8.1B the cupboard in the left corner was for keeping the class's sanitisers, face masks and teacher's resources. So, face masks were reserved for learners who came to school without a mask.

8.2.3 Mburu

Mburu is also a male teacher from a rural combined school. His school is about 15 km away from the town of Nkurenkuru, surrounded by temporary structures as teachers' accommodation. It is a medium-resourced public school in the circuit with an internet connection, science laboratory, computer lab and a decent administration block. Learners prepare their daily meals right after period 8 as well as after the afternoon silence study. At the time of this study, Mburu's class had 14 learners (eight boys and six girls).

In Figure 8.1D, the computer lab at the school assists him a lot as he is able to make some of the resources he needs like worksheets and assessment tasks. It is not only the participating teacher who benefits from the computer lab, instead, other teachers also come and prepare for the next day's lessons. Their computer lab was funded by the Directorate of Education, Arts, and Culture through the School-link programme. Sometimes, learners from all Grades come to the lab and do their activities such as homework and projects, particularly in the subject of information and communication to enhance their skills in technology.

8.3 Mediation of Learning in the Co-developed Exemplar Lessons

Accordingly, Shulman (1987) postulated that a teacher has to turn the subject matter over in their mind before transferring it into teachable components. Taking guidance from Shulman (1987), the Grade 10 Physics teachers collaboratively co-designed exemplar lessons that integrated IK to answer my research question 4: *How do Grade 10 Physics teachers mediate learning of the co-developed exemplar lessons?*

8.3.1 Analysis of Kaurungi's observed lessons

Kaurungi was teaching at a township school which made her proud in terms of network coverage and healthy facilities.

Observed Lesson (OB) 1: Transfer of thermal energy: Convection

Her first observed lesson was on the transfer of thermal energy: Convection. This lesson started by asking learners to stand in a row to receive a handout from their teacher. She started with a learner in front and once this learner received the handout, then they moved to the back until all had received them as shown in Figure 8.2 below.



Figure 8.2: Involving learners in demonstrating convection current activity

The teacher allowed her learners to relate the activity to the topic of the day – convection – as they moved from in front to the back after receiving the handout and explained: “*I got the handout, and then I need to leave and give opportunity for others to follow. After receiving a handout, like I pick up weight and then, I have to rest*”.

The teacher explained the concept of convection to justify the meaning of the activity demonstrated in the class and to clear up the learners’ doubts about convection (to consider this video please go to: <https://drive.google.com>). Then, she referred to convection as the transfer of heat by the movement of a fluid (liquid or gas) between areas of different temperatures. The lesson addressed the specific objective that learners should define convection as the flow of liquid or gas caused by a change in density, in which the whole medium moves and carries heat energy with it.

Moreover, Kaurungi continues to explain that that is why the side of their bodies facing the fire got hot, while the side facing away from the fire stayed cold. Hence, modern classrooms need indigenous practices in them. She connected with how the family was sharing the animal behaviours of animals like hyena-*Simbundu*, honey badger-*Mburu*, and jackal-*Mbanze* – everyone sitting beside the fire gets the same amount of heat from the fire through thermal radiation.

Hyena is a nocturnal person, rarely seen though fairly abundant, powerful but cowardly, a feeder of carrion and addicted to grave robbing. This teaches about scavengers.

Jackal is a person who does dishonest or humiliating tasks for another.

Honey badger is a person who dares to meet her or his goals and never gives up on his projects. Always ready to defend its boundaries.

The head of the family always encourages the members to act like the honey badger to meet the set target.

Kaurungi allowed learners to discuss and present the daily life applications of convection as indicated in Moreno-Guerrero et al.’s (2020) study that the learners should be allowed to experience different learning styles in a familiar and supportive environment. Learners were able to reveal the daily life applications discussed in their groups as shown below as practical example of convection.



Figure 8.3: Kaurungi presented a daily life application on convection

As an example of a daily life application, Kaurungi explained that convection needs a medium like liquid and gas while showing Figure 8.3 to the learners in which the entire medium moves and carries heat energy with it. The movement of boiling water in a pot is also an example of convection. For instance, stirring a pot of soup would be considered a form of convection as it redistributes the heat from the bottom of a pot throughout the soup. She asked learners what happens when boiling water in a pot as shown in Figure 8.3. The group leader of the Grade 10 Physics learners reported that:

The water at the bottom becomes hot and rises and cold water from the top move down. Hence, water becomes hot and rises and cold water from the top moves down and the process continues till all the water gets heated.

This group demonstrated that energy flows along with the medium. In addition, the teacher explained that convection only happens in liquids and gases.



Figure 8.4: Kaurungi clarifying the explanations of Figure 8.3

During the convection lesson, the teacher again explained that the heat from the fire is transferred via convection discharges straight into the atmosphere and would never reach the people around it. For instance, hot air moves upwards. Therefore, thermal radiation is a form of light, and light travels out in straight lines. The side of your body facing away from the fire is literally in shadow and cannot receive the thermal radiation.

Lastly, in this observed lesson learners explained that convection current plays an important role in the refrigerator system in the shops and warehouses. The cold air is released by the air-conditioners. At that moment, this cold air is denser than the warm air and hence, it sinks. The warm air, being less dense, rises and is drawn in by the air-conditioner. As a result, a convection current is established, and the room is cooled.

Observed Lesson (OB) 2: Refraction of light

Kaurungi's lesson two was on the refraction of light. The main focus was on learners finding out the daily life applications of the refraction of light. Learners were encouraged to narrate the necessary applications of refraction and even their practical examples of it. Afterwards, learners were provided with materials to carry out an activity on refraction and tell the entire class about the traditional beliefs about the rainbow and relate it to the refraction of light as well as the bow fishing arrow. The main activity of the observed lesson was for learners to observe refraction from a PowerPoint presentation of the two young boys who were using bow arrows for fishing. In doing

this, the teacher asked learners to group themselves and sketch their observations on A4 papers. Learners were also allowed to carry out a hosepipe activity in the afternoon to observe the refraction and dispersion of light in water drops (rainbow) and compare the rainbow they observed during the outside classroom lesson.



Figure 8.5: Refraction of light in bow fishing arrow

After learners were engaged in the fishing activity, they were able to see the arrow was refracted, that is, it looked bent when entering the water. As a result, the learners were able to sketch and label the diagram as shown in Figure. 8.6.

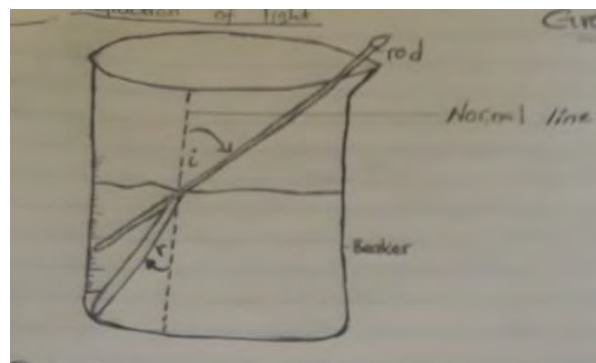


Figure 8.6: A sketch of Grade 10 Physics learners of bow fishing arrow from Figure.8.5

The figure below shows how learners observed the refraction and dispersion of light in water droplets and saw the spread of white light to show the rainbow colours.



Figure 8.7: Kaurungi’s learners viewing the dispersal of light: Rainbow

Moreover, Kaurungi’s learners shared their cultural beliefs about the rainbow. They said that there are two cultural beliefs associated with the rainbow:

1. *In Christianity, a rainbow promises better times to come, and there will be no flood again.*
2. *The rainbow is a very brightly coloured snake that appears to stop rain that has been made by their enemies then we hear the thunder.*

Kaurungi continued to explain about the rainbow which usually appears during the rain time, but it can occur wherever light is being bent inside water droplets. Thus, a rainbow can be seen in mist, fog, spray and dew. Eventually, rainbow- *ekongoro* is made up of all seven colours that come from light. These colours are *red, orange, yellow, green, blue, indigo and violet*. Equally, it could be deduced that when the culture of science generally harmonises with a learner’s lifeworld culture (Ogunniyi, 2007a), science instruction will tend to support the learner’s view of the world and the process of enculturation tends to occur (Aikenhead, 2021).

8.3.2 Analysis of Lyako’s observed lessons

This is a male teacher as already indicated in Table 8.1 of this chapter. As I said, he had a Bachelor’s Honours degree (BEd) in science education. At the time of this study, he was also doing his master’s degree in Educational Psychology.

Observed Lesson (OB) 1: Conservation of energy: Form of energy (kinetic and potential energy)

The first lesson for this teacher was about the forms of energy – kinetic and potential energy. He started the lesson by asking if his learners knew anything about these forms of energy. Learners gave a few explanations about kinetic energy such as moving, swinging, pulling water from a well-*Ndjombo* and diving into the Kavango River.

Learners attempted to provide different answers as stated in the paragraph above. Some practical examples of potential energy around the school were a water tank (which is on a stand that is two metres high), dishes on a 1-metre stand and pounding millet. To start teaching about the forms of energy, Lyako asked learners to look at the flag and tell what form of energy it possessed while hanging. A group of learners agreed that a flag possessed potential energy. He then continued to explain to his learners about kinetic and potential energy. Lyako continued to explain what the kinetic and potential energy are as shown in Figure 8. 8.



Figure 8.8: Swinging to mediate the concept of potential and kinetic energy

The teacher used a range of local activities in his class that possess potential and kinetic energy as alluded to in Mavhunga and l.'s (2016) study that there is value in using representations to support learning. These artefacts were familiar to the Grade 10 Physics learners. Lyako continued to explain how swings operate by converting potential energy into kinetic energy, then kinetic energy back into potential energy, over and over again.

So, the kinetic energy is the fast part of the swinging, it is the speed you have as you rush back and forth. The higher you go on the swing, the more potential energy you have as observed in Figure 8.8B. Lyako asked his learners to bring such artefacts to the classroom and then enabled understanding when he explained and asked them to demonstrate how the artefacts operate as shown in Figure 8.9. It could be argued that Lyako used many representations (Mavhunga & Rollnick, 2013) as discussed in the summary of the findings in Section 8.5.



Figure 8.9: Longbow and arrow for kinetic and potential energy

Lyako also explained to the entire class that when *Lingo*²⁶ pulled back the longbow, with the arrow raised, this gave the bow potential energy. As soon as the string was released, the potential energy was converted to kinetic energy in the movement of the arrow. Therefore, the energy possessed by the arrow was chemical energy (stored in muscle) and was converted from potential energy to

²⁶ Lingo is the name of a learner in the participated physics class, who demonstrated the pulling of a longbow with an arrow.

kinetic energy and sound energy. Proportionally, the greater the muscle force the greater the potential energy and kinetic energy produced by the arrow. On the contrary, when the muscle force is small the potential energy of the string will be weak and the arrow slow. Below I present data for observed lesson two.

Observed Lesson (OB) 2: The basic concepts of light: Shadows

The second observed lesson was on the basic concepts of light. Learners were provided with different materials to demonstrate the concepts: transparent, translucent and opaque materials and to demonstrate that light travels in straight lines. Learners managed to bring materials such as glass, a can, a box, a brick and a woodblock for them to observe the materials that would allow the light to pass through. The teacher asked learners to say which materials did not allow them to see things outside the classroom. Many groups of Grade 10 Physics learners said that they could see the informal teachers' houses through the glass window, while they could not see through the wall.

Lyako defined the concept of light stating that light is "*a form of energy and it travels in straight lines. Also, when light is blocked by objects hence, shadows will form*". Materials such as tins and boxes are known as opaque since they do not allow light to go or pass through them. In contrast, glass such as windowpanes allows light to pass through it and is known as transparent, whereas, a glass bottle does not allow all light rays to pass through it and this material is known as translucent. He further used an example of a lunar eclipse to explain how light is blocked by an opaque object(s).

He took the Grade 10 Physics learners outside to do a shadow tracing activity. He also used this practice to explain how community members use the idea to estimate time by using the length of their shadows or an object – this showed the role of shadows in an everyday application. He instructed learners to observe the length of their shadows and the position of the sun. Lyako continued to explain that a shadow is a dimension figure or shape produced by a body coming between rays of light and a surface or the ground.



Figure 8.10: The position of the sun and the shadow through learners' engagement

These Grade 10 Physics learners realised that a shadow is an area where light from a light source is blocked by an opaque object. Their bodies were examples of opaque objects, while the sun was a primary source of light. Lyako further explained that elders in the communities use shadows to estimate the time when they want to knock off for lunch.

8.3.3 Analysis of Mburu's observed lessons

Mburu was teaching in a medium-resourced public school and his school had internet, a science laboratory, a computer laboratory and an administration block. He was an experienced teacher, with great potential skills in the teaching of Physics. Mburu had taught at numerous public and private schools.

Observed Lesson (OB): Reflection of sound

Mburu's lesson was on the reflection of sound. He began his lesson by telling a story about a couple who were invited to attend a wedding party in the neighbouring community. The couple had agreed about who should attend the wedding party or not. The wife decided to approach their natural family lawyer. The lawyer was the river, who would determine who would go and who would stay as shown below in Figure 8.11.



Figure 8.11: The riverbank where the couple shouted as to who should go to a wedding and who should remain at home

Based on the story, the husband shouted first to ask the lawyer if he should remain, followed by the wife who asked if she should go.

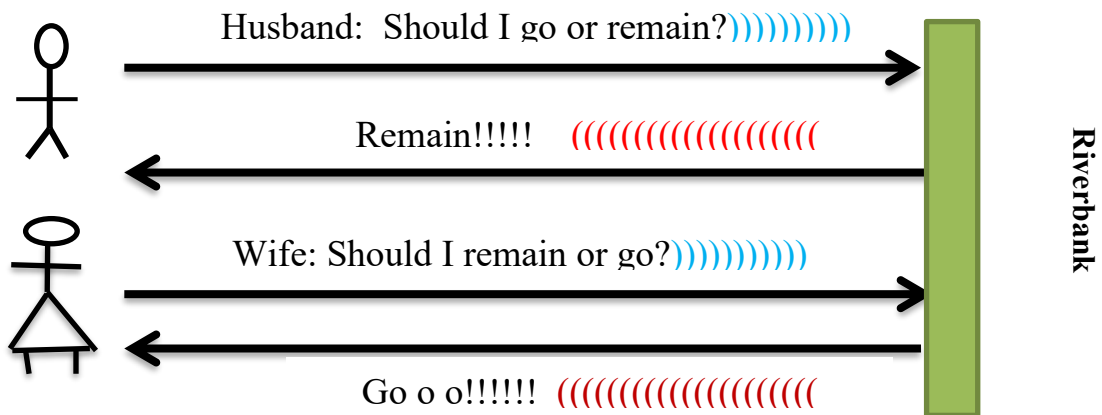


Figure 8.12: The moral of the story is all about the reflection of sound: Echo (adapted from Liveve, 2017, p. 72)

Mburu continued to sensitise his learners that the reflected sound for the husband, was for the word saying ‘remain’, while for the wife it was ‘go’. The reflected sound was an echo. This couple only managed to hear the last word from both sound emitters. His Grade 10 Physics learners had their

sketches about the reflected sound as denoted in their groups. In this sense, the reflection of sound waves leads to echoes. Essentially, echoes are different from reverberations. An echo happens when a reflected sound wave reaches the ear more than 0.1 seconds after the original sound wave is heard.

Initially, when sound travels in a given medium like air, it strikes the surface of another medium such as a solid riverbank in the context of the story and bounces back in the opposite direction. Mburu added that an echo is louder at night due to the change in the direction of sound deflection, which is caused by the reversal of the temperature gradient from day to night. The Grade 10 Physics learners revealed that the learner standing 10 metres away from the Physics class shouted for 0.1 seconds and then she heard her sound after 0.2 seconds. Thus, they concluded that she heard her reflected sound. Learners discussed the real-life applications of echoes:

- The fisherman uses echoes to find the depth of the sea.
- Echoes are used in the hospital to view the dimension picture of a fetus by using ultrasound scanning.
- Bats use echoes to navigate and find insects to eat using echolocation.

Mburu continued to explain echolocation, that it produced sound waves at frequencies above human hearing. Similarly, bats emit sound waves that bounce off an object in their environment, then the sounds return to the bats' ears, which make quick turns to recognise the signals.

8.4 Emerged Themes of the Observed Lessons

The analysed data, discussion and research questions for this chapter of the study were to build on the themes that emerged for this chapter. Themes served as a touchstone to show that participating Grade 10 Physics teachers were engrossed in expansive learning when teaching Physics concepts using both IK and WKS. The themes that emerged are shown in Table 8.2 below.

Table 8.2: Themes that emerged from observed lessons

Source of data	Themes	Theories/literature	Research question
Communal learning, document analysis and reflections	Culture of learning and materials	Socio-cultural, CAT and cooperative learning	4
Lesson observations, reflections and document analysis	Learners' prior knowledge	ZPD, constructivism, socio-cultural and cultural heritage	
Lesson observations, reflections, document analysis and stimulated recall interviews	Representations and visualisations	TSPCK and modelling	

In this chapter, I managed to observe five lessons from three Grade 10 Physics teachers in their various classrooms. However, I did not let other three Grade 10 Physics teachers come and observe these lessons which was unfortunate as they would have had the opportunity to validate whether IK can play a role in the learning and teaching of science. To understand an individual's thinking, one needs to appreciate the social, cultural and historical contexts in which it occurs (Lee et al., 2020). Below I discuss and present themes that emerged in this phase four of the study.

8.4.1 Culture of learning and materials

In this theme, I use the term communal instead of individual to refer to group work done during the learning process. Subsequently, in the high communal learning context learners worked together in groups of three or four (Maddusila, 2020), this was motivated by dialogical argumentation (Ogunniyi, 2007a). In observed lessons, particularly in Kaurungi's lesson, learners were able to learn the concept of refraction through group work and sketched incident and refraction angles and deduced the everyday applications of refractions in their immediate communities (Gwekwerere, 2016). It was revealed that the Grade 10 Physics learners had great opportunities to share their opinions during the group discussions. This finding has resonance with Monaci (2020) who writes that culture is a contextual lens through which people view and

understand the world, and has a direct influence on learners' cognitive processes and understanding of science.

8.4.2 Learners' prior knowledge

All observed lessons revealed that all three Grade 10 Physics teachers introduced their lessons by building on the learners' prior knowledge either from the previous lesson and/or from their immediate environments. That is, they all presented intensely interesting lessons and connected with the learners' everyday experiences as reiterated by Gwekwerere (2016). In the case of convection current, for instance, they had practical knowledge of how a fire starts and how warm air reaches people sitting around it as well as cold air that leaves from the top into the surroundings. As a result, most learners were able to relate their personal experiences of heat from a fire, expressing the daily applications of convections as reported during their group work.

8.4.3 Representations and visualisations

All three Grade 10 Physics teachers worked hard to use analogies in their teaching of their co-developed exemplar lessons. Kaurungi, Mburu and Lyako's observed lessons made use of representations and visualisation to support learners' ZPD in the learning of the presented concepts of the Grade 10 topic. For instance, Lyako used the representation component of TSPCK during his teaching of kinetic and potential energy using a longbow and arrow. Taşar (2010) claims that learning activities should start from the known to the unknown, and/ or from the easy to the complex with the aid of the learners' prior knowledge as revealed in their teachings.

8.5 Discussions of Findings of the Observed Lessons

The observed lessons were conducted in three schools around the Kandjimi Circuit of the Kavango West Region. Observations enabled me to access interactions in a social context and yield systematic records of these interactions which supplemented other types of data (Cohen et al., 2018). I adopted a participatory approach (Ngcoza & Southwood, 2019) underpinned by principles of Ubuntu (Ogunniyi, 2007a) and informed by the TIMESD framework. The TIMESD is significant when designing, implementing and improving IK integrated science lessons (Chikamori et al., 2019).

There was a major shift in the second observed lessons of the Grade 10 Physics teachers' understanding of how to integrate IK into science teaching. When compared with their first round of observed lessons, one could see that the teachers gained some confidence to explore the different types of indigenous technologies and ways of integrating IK. As a result of the intervention of *drum making, drumming, music and dance*, the teachers began to see science as a subject that can be taught using easily accessible resources from learners' everyday lives (Asheela et al., 2021; Gwekwerere, 2016; Shinana et al., 2021). There was also evidence of an expanded view of IK from viewing it as ancient knowledge to viewing it as the knowledge that is applicable in modern-day life. One can safely argue that the teachers' knowledge, attitudes and professional insights regarding the integration of IK shifted from being a novice to a grandmaster. Having said this, it is important to turn to the benefits for the participants that they credited to this intervention. Interestingly, lesson observations were used extensively in this chapter of the research, classically to explore teachers' intellectual processes while reflecting on their teaching following a teaching experience (Paskins et al., 2017).

The CAT categories (Ogunniyi, 2007a) provided a framework to analyse the underlying motives of using cultural heritage as a tool. Also, I drew on Vygotsky's (1978) SCT which is based on the principle that learning is a product of social interactions involving adults, peers and teachers. Moreover, to introduce their lessons and to make sure that learners understood the activities, the Physics teachers seemed to use a question-and-answer method (see how Kaurungi had introduced her lesson as you follow the link <https://drive.google.com>). In my opinion, the technique of question and answer that they used to introduce their lessons seemed to be useful; yet, there were missed opportunities where these learners could have engaged further with the topic taught with their peers and with the teacher.

8.6 Participants' Experiences and Benefits

In this section, I report on how both community members and Grade 10 Physics teachers reacted as soon as I provided feedback about the rich knowledge of my findings that I had obtained from them during workshops. The majority of the participants expressed their experiences and benefits of being involved in the research project as expanded in the next section.

8.6.1 Expert community members

Expert community members (ECMs) demonstrated and explained the *drum making, drumming, music and dance* and the engagement varied; several key opportunities were commonly identified.

For instance, Otate Matia mentioned the following during the talking circles:

Kugwanekedesa ukumwe merongo, nokudimburura nkedi zokutambura ekohonono zompumbwe. Kuninkisa vakali mo womonkarapamwe navenye valihamesere mefukunyo rongo eli alikwatakana nkarapamwe kumwe noSure valironge Unkurungu wavene ou wakundurukida. Vharerwa zomukunda ava-ava lihamesere mwa ga makonakono rongo kulikida elituro mo mokuvatera sirongwa sangesi sihoroke [Increases the opportunities that solutions would be widely accepted. Citizens (community) who participate in these processes show significant commitment to help make the study happen].

Equally, Onane Mukwasipika acknowledged the benefits of being involved in the research: “*Drawing on local knowledge from a diverse group creates solutions that are practical and effective ... working together improves communication, confidence and understanding within our Unongo Youth Cultural Group*”.

During the discussions, Onane Mukwanzadi further expressed that “*Ame kwalizuvire uwawa mokumona varongi wokuronga harade 10 mosirongawa zounkurungu amu vanakututemwinina oku tava myaka. Kwalikidire ukumwe, eharo lyompo zawo, novakali mo vawo*” [I was pleased by seeing Grade 10 Physics teachers imitating us as they were dancing, in doing so, they demonstrated harmony and honouring their immediate culture]. In this regard, Onane Mukwankora reflected that: “*Certainly, our involvement in the research project has advertised our Unongo Youth Cultural Group to the various events, even schools within the Kandjimi Circuit do invite us to train learners on cultural concerts*”.

During the talking or sharing circles, as emphasised by Chilisa (2012) and Lavallée (2009), ECMs expressed that they gained the confidence to be able to explain their indigenous technologies successfully. Equally, by working with Grade 10 Physics teachers, they realised that IK was very valuable in science classrooms.

8.6.2 Grade 10 Physics teachers

It seems that the Grade 10 Physics teachers had several benefits such as a sense of empowerment by taking an active role in their teaching approaches to improve the quality linkages between school, families and community. For instance, Kaurungi stated that *“I was engaged in the research project and is of vital importance as I am executing my role in teaching these learners through storytelling; relate the scientific concepts to the everyday experiences of learners ... I acquired numerous skills such as drumming skills from different sizes of drums”*. She further stated that:

During this research project, I experienced that research can help individuals in finding answers to things that are unknown. Improved the ways I conduct my Physics lessons. Again, being involved in the research enabled me to understand the chosen field both outside and inside the classroom.

In addition, Kaurungi stated that involving indigenous technologies forms an authentic teaching aid that helps learners to understand most of the Physics concepts of Grade 10. To CAT, science and IKS worldviews complement each other (George, 2021); hence they are equipollent, and learning does not happen in isolation (Ogunniyi, 2007a). In the same vein, Kondjereni highlighted that *“The study acted like the lens for me to grasp many daily applications which learners do at home, seems to be similar to what they do in both of their Physics and Chemistry classrooms”*. Kondjereni reflected that *“I saw how indigenous knowledge complemented western science”*. He was referring to the way girls in the community separate flour from pounded Mahangu grain by the process called sieving-*kuhesa* as shown in Figure 8.13.



Figure 8.13: A community girl sieving the fine flour particles to pass through the holes of the sieve

In Kambinda's expression, many young men can conduct science in the natural world – this can be done within a family, as part of the day-to-day activities such as streaming and smoothening their sledges to reduce the friction when being pulled by oxen as shown in Figure 8.14. In the case of CAT taxonomy, this Physics teacher seemed to have a dominant scientific worldview, with IK being suppressed or assimilated.



A



B

Figure 8.14: Types of sledges as a mode of transport in the Ukwangali community

The sledge at A which is in an acute shape makes it easy for the oxen to pull since the front part is streamlined and smooth while the sledge at B in the form of a parallel structure is much more difficult for the oxen to pull because the parallel poles of the sledge easily go deep in the sand. Similarly, the Grade 10 Physics teachers expressed that the interactions enabled them to also learn from each other and the ECMs.

8.7 Chapter Summary

This chapter presented and discussed data for research question 4 on how Grade 10 Physics teachers mediated learning of the co-developed exemplar lessons. Only three of the six were conveniently sampled to mediate learning of the co-planned exemplar lessons in their classroom settings and I regret not allowing other Physics teachers to come and observe these lessons.

Teachers' knowledge and beliefs might limit the extent to which they engage their learners in scientific argumentation and science teachers' PCK of argumentation, addressing both structural elements and the dialogic processes involved, shapes how they implement IK integration. The Grade 10 Physics teachers' epistemological beliefs acted as an amplifier filter or guide for both teachers' learning of argumentation and translation into their teaching.

The CAT (Ogunniyi, 2007), DIAM (Langenhoven & Stone, 2013) and TSPCK (Mavhunga & Rollnick, 2017) were the lenses for the intervention of the cultural heritage of *drum making*, *drumming*, *music* and *dance* in which Grade 10 Physics teachers were engaged. Hence, Grade 10 Physics teachers were able to comprehend the major four properties that affect the frequency of the skin used on a drum which was the *length*, *thickness*, *tension* and *density*. Next, I present the summary of findings, reflections, recommendations and conclusion.

CHAPTER NINE: SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSIONS

Essentially, most African learners have accumulated a wealth of holistic knowledge about their environment which school science with its compartmentalized disciplines has tended to displace rather than accommodate. (Ogunniyi & Ogawa, 2008, p. 182)

9.1 Introduction

The epigraph above suggests how learning might be perceived and transformed in cultural settings. Thus, what this study has done was an attempt to mobilise the ²⁷indigenous technology of *drum making, drumming, music and dance* for cultural revitalisation and indigenisation of the science curriculum.

This final chapter presents a summary of my findings, recommendations, acknowledgements of limitations, reflections on my PhD journey and the conclusion. Tracy (2019) highlights that in writing the sections that make up this chapter, the contents of earlier chapters should be examined as a whole. In this chapter, a summary of my findings is presented in relation to the research questions. It starts with a brief overview of the study. This is followed by a presentation of the summary of the findings, the new knowledge generated, participants' experiences and benefits, recommendations and suggestions for areas for future research. Lastly, the chapter offers the limitations of this study before turning to my reflections on the research journey and finally the conclusion of this study.

²⁷ As explained earlier, indigenous technology (Emeagwali & Shizha, 2016; Gumbo, 2020; Shinana et al., 2021) is used instead of indigenous practice.

9.2 Overview of the Study

As already discussed in the previous chapters, the main goal of this study was to mobilise the indigenous technology of *drum making, drumming, music* and *dance* for cultural revitalisation and indigenisation of science. To achieve this goal, the following four research questions were addressed:

Research Questions

1. What are Grade 10 Physics teachers' experiences, pedagogical insights, and attitudes toward the use of IK in science teaching?
2. How do the Grade 10 Physics teachers interact, participate and learn (or not) during the ECMs' practical demonstrations and explanations on *drum making, drumming, music* and *dance*?
3. How do the Grade 10 Physics teachers integrate the cultural knowledge from the community members on *drum making, drumming, music* and *dance* when co-developing exemplar lesson plans?
4. How do Grade 10 Physics teachers mediate learning during enactment of the planned exemplar lesson in their classrooms?

To answer each research question, I used several data gathering techniques. For research question 1, for instance, semi-structured interviews were used. I found these to be beneficial as the researcher, as they allowed me to access first-hand information from the seven Grade 10 Physics teachers who participated in this study. For research question 2, data were gathered through participatory observations, participants' reflective journals and stimulated recall interviews. The main focus of this research question was on how the Grade 10 Physics teachers interacted, participated and learnt (or not) during the ECMs' practical demonstrations and explanations on *drum making, drumming, music* and *dance*.

For research question 3, similar to Nhase's (2019) study, a group reflective space was deemed essential as one of the data gathering processes. This was consistent with the professional learning community centred in this study. Meanwhile, phase four envisaged the development of PCK for the six Grade 10 Physics teachers through co-developing exemplar lessons. To answer research question 3, therefore, group reflections, discussions and workshop presentations were used. Such

a reflective space afforded the teachers involved in this study and me an opportunity to reflect on the lessons learnt. Research question 4 involved lesson observations, to examine the Grade 10 Physics teachers' understanding of the integration of indigenous technologies when teaching their co-developed exemplar lessons in their science classrooms, that is, putting theory into practice.

9.3 Summary of Findings

This section highlights and summarises the key findings that emerged from the study. As alluded to earlier, the findings are presented in relation to my research questions.

9.3.1 Research question 1

What are Grade 10 Physics teachers' experiences, pedagogical insights, and attitudes toward the use of IK in science teaching?

The findings for my research question 1 revealed that the six Physics teachers in this study had some understanding of cultural heritage and the artefacts that could be used in science teaching. However, they indicated that they found it difficult to engage with cultural heritage highlighting the absence of technological resources, for example, when calculating the kinetic energy in their classroom settings. Notably also, is that during the semi-structured interviews these Grade 10 Physics teachers did not mention anything about *drum making, drumming, music and dance* as a potential resource to teach science concepts such as sound waves and other related science concepts. Such a finding pointed to the importance of this study.

For instance, all the Physics teachers involved in this study indicated that the curriculum seems to order them to put Western knowledge ahead of IK when teaching science concepts in their classrooms. This finding is congruent to Ogunniyi's (2007a) dominant cognitive state, whereby WS is prioritised at the expense of indigenous knowledge. However, they suggested numerous indigenous technologies that could be used to teach science concepts. For instance, a simple tool used by the community when fetching water from a deep well. Kambinda reported that a rope is used for raising, lowering or moving a bucket full of water as a load, and the whole activity is just to make work easier. Further engagements resulted in other examples of potential indigenous technologies such as churning fermented milk and heating metals through malleability that required knowledge from the ECMs.

9.3.2 Research question 2

How do the Grade 10 Physics teachers interact, participate and learn (or not) during the ECMs' practical demonstrations and explanations on drum making, drumming, music and dance?

The Grade 10 Physics teachers were eager and willing to establish mutual corporation with the Unongo Youth Cultural Group in all aspects, for instance, in the division of labour. It emerged that the construction of musical instruments comprised a wide assortment of skills that employ different materials that are found in the environment.

When the ECMs demonstrated and explained to the Grade 10 Physics teachers, they observed that a trunk from the Mangetti or *Muwowo* tree was deemed suitable for drum making since they are light and lose water gradually without cracking. The skin must be soaked in water and hairs are removed by using a sharp knife – the sharp knife demonstrates the explanation of teaching the topic of area and pressure – that is, the smaller the area the greater the pressure. That is why the edge of the knife is therefore sharp. The drum maker explained that if the hairs are not removed, that would increase the amount of friction between the palms and a stretched skin leading to a bad alteration of sound. The drum is brought nearby the fire and heated by thermal radiation which warms the skin over the head of the drum and makes it stretch without contacting the fire.

In this regard, the Grade 10 Physics teachers demonstrated the ability to learn about concepts related to *drum making, drumming, music and dance*. Regarding materials used, thickness, head type and drum depth – all of these can affect the volume and sound of a particular drum which also affects the dance. The ECMs have a crucial skill in placing the wax which improves the sound quality specifically the bass. The use of the drum in demonstrating how sound is made represents the use of easily accessible materials in which the drum membrane produces sound by vibrating (Asheela et al., 2021). Likewise, the Grade 10 Physics teachers' approaches to teaching Physics were generally considered to be linked to their views about the Physics linked to *drum making, drumming, music and dance*. As a result, Lyako's lesson was on the reflection of sound.

9.3.3 Research question 3

How do the Grade 10 Physics teachers integrate the cultural knowledge from the community members on drum making, drumming, music and dance when co-developing their exemplar lesson plans?

The Grade 10 Physics teachers were able to learn Physics-related concepts embedded in the indigenous technology of *drum making, drumming, music and dance*. The answer to this research question revealed that social interactions facilitated sharing and understanding of everyday experiences (Taheri et al., 2021; Vygotsky, 1978). For instance, the Grade 10 Physics teachers prepared their exemplar lessons where they integrated cultural technologies. In light of this, culturally responsive pedagogies helped the Grade 10 Physics teachers to understand how culture influences learning and helped them develop cultural knowledge and connect it to their classrooms (Mhakure & Otulaja, 2017). Gay (2018) showed that when both teachers and learners in an environmental science class were included in the shared decision-making process to create school projects relevant to their community, they felt not only academically empowered but also socially empowered.

In their discussions, Kaurungi revealed that the use of Grade 10 Physics learners' cultural experiences of the rainbow (*Ekongoro* in Rukwangali and *Inkongolo* in Runyemba) could enhance his learners' engagement, argumentation, meaning-making and conceptual insight when teaching the concept of refraction (see Figure 8.7). In this regard, the Grade 10 Physics teachers seemed to display the equipollent view of IK in the CAT categories (Ogunniyi, 2007a). In their discussions, it was further revealed that learners in their classes described the cultural belief about the rainbow being an animal and learners thus seemed to display a dominant indigenous worldview in the CAT classification (Ogunniyi, 2007a). In a nutshell, during the demonstrations and explanations, the Grade 10 Physics teachers realised that the heating of metal by using a blast furnace-*Muvandje/mudukuto*, could be a perfect artefact to mediate learning of the topic of *malleability* since metal is capable of being shaped or formed by hammering (Kudumo, 2020).

9.3.4 Research question 4

How do Grade 10 Physics teachers mediate learning during enactment of the planned exemplar lesson in their classrooms?

The primary role of this research question was to examine the Grade 10 Physics teachers' understanding of the integration of indigenous technologies when mediating learning of their exemplar lessons. The findings revealed that the Grade 10 Physics teachers had acquired the relevant skills to be able to integrate indigenous technologies. For instance, Kaurungi explained the indigenous technology of sitting around the fire during the sharing circles as shown in Figure 7.9 can be used to explain convection as the flow of heat.

9.4 New Knowledge

The first unique contribution to new knowledge in this study lies in its focus on decolonising the curriculum through mobilising the indigenous technology of *drum making, drumming, music and dance* for cultural revitalisation and indigenisation of the science curriculum. This is new knowledge because I have not come across any studies conducted, especially in Namibia or in Southern Africa, on the same aspect. Admittedly, although the integration of IK is supported by the curriculum in Namibia, there is a lack of specific examples of what IK to integrate and how it can be integrated. Moreover, while many studies have been conducted on how to integrate IK into science education, I have not come across any study that focused on how to integrate the indigenous technology of *drum making, drumming, music and dance*.

In addition, the study also demonstrated how the curriculum can be decolonised and indigenised using the bottom-up approach (Mutanho, 2021; Seehawer et al., 2022). In the context of this study, the bottom-up approach entailed working with teachers in tapping into the cultural heritage of the community members rather than relying on the 'one-size-fit-all' and once-off workshops run by the Department of Education (top-down approach). In this regard, the study's uniqueness lies in that it offers a practical example of how the Namibian teacher education science curriculum can be decolonised through the integration of IK. Unlike studies such as Mutanho (2021) which advocate inviting ECMs to share their IK with teachers, the Grade 10 Physics teachers went to the community members to learn and interact with them in their own environment – out-of-school

context. In addition, unlike Simaisku's (2022) study whose community members were identified based on individual expertise, my ECMs were the organised members of the Unongo Cultural Youth Group.

Hence, it can be argued that this study takes a unique approach in giving a *voice* to the ECMs by respecting not only their knowledge and wisdom but also their dignity, culture and environment. As a result, the community members realised that their knowledge and wisdom were valued and most importantly could be used to make school science accessible and relevant to learners. In this way, a case is presented that teachers should not wait for the community members to come and share their knowledge, instead they should go out to seek information in a manner that respects the communities in which they work and their cultural practices. Thus, the partnerships between schools and communities should not be unidirectional relationships as suggested by Mutanho (2021), but a dual relationship based on mutual benefits. Below I spell out the new knowledge that surfaced from my study:

- 1) The importance of getting teachers' perspectives and pedagogical insights before engaging in an interventionist study was fundamental to unearth or surface their level of understanding of IK integration before the intervention. Such information was useful in informing the study and in acknowledging that these teachers were agents of change.
- 2) The use of an out-of-school context or setting in learning other ways of knowing, doing and being from the ECMs' practical presentations and explanations on the indigenous technology of *drum making, drumming, music and dance*. That served to revitalise the IK, thereby making science accessible and relevant to the life worlds of the Physics teachers involved in this study.
- 3) Giving *voice* to community members who are the custodians of the cultural heritage and whose knowledge and wisdom have been marginalised and invisible for years. Resultantly, the community members came to realise that their knowledge is valued and relevant to school science. The mutual benefit is that the community members were afforded an opportunity to listen to the scientific explanations during our discussions.
- 4) Learning to use *stories* to mediate learning of science and this knowledge is crucial to how STEAM could be enriched. It thus emerged in this study that storytelling, which is an indigenous methodology in which indigenous peoples pass on knowledge from generation to generation, has a great potential to relate science to learners' everyday life worlds.

- 5) Our PLC enabled us to co-develop exemplar lessons using easily accessible resources that integrated IK from the environment and enacting such lessons was useful in improving their PCK. The PLC members are positioned as the cultural knowledge brokers (Wyatt, et al., 2017).
- 6) Finally, consistent with indigenous research methodologies, we showed respect to the community members by validating the findings around the fire and employing talking or sharing circles (Chilisa, 2012; Lavallée, 2009). During such an indigenous validation process, the ECMs were able to reflect in the language of their choice, particularly the Rukwangali dialect and they appreciated the experience.

9.5 Limitations of the Study

It should be acknowledged that every research study has its strengths and limitations. This study is no exception. The study was conducted in the community of Ukwangali, in the Kandjimi Circuit in the Tondoro constituency of the Kavango West Region of Namibia. It was conducted with six Grade 10 Physics teachers from three schools. It is for that reason that the six participants, three schools and the Unongo Youth Cultural Group of Yinsu Village do not represent the whole population of the Grade 10 Physics teachers in the Kavango West Region as well as the cultural groups in the Ukwangali community. Therefore, the study cannot be generalised. Notwithstanding such a limitation, the study provided some insights on how Grade 10 Physics teachers developed Physics ideas from cultural heritage demonstrated and explained by the ECMs. Regarding lesson observations, it was also noted that the camera could not capture the body expressions of all learners when they spoke and when other learners spoke, due to the limited view of the camera, from the angle where the activity was filmed.

Because of the aforesaid limitations, if I were to do this study again, I would consider the following:

- To observe all six participating Grade 10 Physics teachers, consolidate and validate the findings and gauge the experience, pedagogical insights and attitudes toward the use of IK after being engaged in the co-developed exemplar lessons.
- It would be an opportunity to allow the teachers who did not teach the co-developed exemplar lessons to come and observe so that we could reflect together thereafter.

- To invite an expert to translate from mother tongue to English, in this case, Rukwangali to English and/or Runyemba to English. Though the mother tongue plays a vital role in encouraging participants' discussions and engagement as reiterated by Salö et al. (2018), I was mindful of the fact that by translating from the mother tongue to English, some information might have been lost through misinterpretation.
- In this study, participants and I could not sit closely during the semi-structured interviews because of the COVID-19 regulation of social distancing. I could not record the participants' voices during interactions and discussions were sometimes not clear because they wore COVID-19 protective masks. Therefore, if I were to do this study again, I would use a multifunctional digital voice recorder device so that I could audio capture all discussions without any interference. This would improve the quality of data in both semi-structured interviews and stimulated recall interviews.
- To allow Grade 10 Physics to videotape their lessons and then watch them together and analyse their PCK about the IK integration.
- To invite school principals of the participating Grade 10 schools so they could be afforded an opportunity to acknowledge the rich knowledge from their communities.

9.6 My Reflections

The hardship of this study was that of data generation. The data generation started in the year 2019 and some of the issues were school closures (like a school in Nda-Kulanda – the school did not have portable water and ablutions), ensuring continuity of learning for all learners, learning from home (distance learning via TV, WhatsApp and so on). Although I managed to generate data in this research, it was not easy to work with all six and/or three teachers as a group. They were repeatedly absent because of responsibilities at their schools. I had to visit them more than a few times to negotiate with them to meet with me. Due to Covid-19, it was also a challenge to set up a programme, providing all necessary facilities and fulfilling all protocols and regulations related to the fight against the spread of the Covid-19 virus.

Sadly, on the 10th of January 2022, I lost my sister Kamahia Paulina Kandindi, although it was not a Covid-19 related death. It was hard since I was very keen to catch up on the due date of working on the comments and suggestions. I was hoping that I would manage to submit by the March 2022 deadline but instead I ‘ran after two hares and caught none’.

During the meeting of community members, they offered us some traditional lunch and this resonated with the spirit of Ubuntu as reiterated by Ogunniyi (2018) and Seehawer (2018a). It was remarkable to revisit the ECMs to strengthen trust with them. The ethical matters in research and analysis of findings in unbiased ways were cautiously deliberated as per requirements. Most importantly, the use of the vernacular languages of *Rukwangali and Runyemba* as the mode of communication when meeting with ECMs was useful in building our trust.

With literature, context and guidance from my supervisors during this journey, I realised that exploring the integration of IK in science teaching provided opportunities for teachers to connect scientific concepts to the learners’ everyday life experiences as emphasised by Gwekwerere (2016). On the whole, the research process introduced me to many new ideas which I had to develop in language, vocabulary and academic research writing. Sometimes it was difficult to go through the unfamiliar concepts from literature as well as comments and suggestions from supervisors. However, I learnt a lot through revising and redrafting ideas until I understood them and could made them clear to my supervisors and the readers.

9.7 Conclusion

This qualitative case study employed a formative interventionist methodology to explore how to mobilise the indigenous technology of *drum making, drumming, music and dance* for cultural revitalisation and indigenisation of the science curriculum. To achieve this goal, I used multiple data gatherings methods to answer my research questions, namely semi-structured interviews, observations (participatory observation and videotaped lessons), group discussions and journal reflections. I video recorded these interactions with the ECMs and the Grade 10 Physics teachers. The Grade 10 Physics teachers learnt the ways of integrating IK during workshops and interventions. I also positioned myself as a co-learner and provided regular feedback after each session and the Grade 10 Physics teachers were regarded as co-researchers in this study. That is, I did the research *with* them rather than *on* them as reiterated by Ngcoza and Southwood (2019).

This study contributes to the decolonisation of a Western-based curriculum that seems to disregard the cultural heritage of an African schoolgoing child. This was made possible through collaboration with ECMs who are the custodians of IK. It also emerged that in this study, home language was a valuable cultural tool of communication (Khupe, 2014). Primarily, the study revealed that the Grade 10 Physics teachers learnt communally and were able to identify cultural technologies which were integrated during the mediation of teaching co-developed exemplar lessons.

This study further revealed that the integration of IK has the potential for increasing understanding of science concepts during lessons (Samad et al., 2021). Instead of relying on written literature, which is often written from Western approaches, this study assists in giving *voice* to postcolonial indigenous communities. The uniqueness of my study is that I traditionally addressed this topic by using a PLC opportunity and immersing myself in the community to tap into their cultural heritage and wisdom, which is transmitted verbally in the form of stories, songs and dance. The findings resonate well with Chilisa (2012) who advocates that culturally pertinent pedagogy should be more evenly disseminated across the classroom, and the teacher viewed as assemblers of knowledge. In addition, the science curriculum should be modified to help teachers' link learners' backgrounds and establish relevancy.

9.8 Recommendations

The indigenous technology of *drum making, drumming, music and dance* proved to be effective in mediating learning of the Physics concept of sound and other associated concepts in this study. Moreover, the Physics teachers in this study were able to transfer the knowledge gained from the ECMs to other indigenous technologies or practices that they could use in their own teaching.

Thus, the study recommends that teachers should work in collaboration with ECMs as custodians of IK to learn about IK which could be integrated into their teaching. This concurs with Omodan and Dube (2020) who claim that the integration of IK paves the way for the Africanisation of the science curriculum (Mukwambo et al., 2014; Seehawer, 2018). This might assist in retaining and sustaining the view of Ubuntu which could result in the progression of the culture and dignity of indigenous people (Skoric, 2017). In my view, there is huge potential for researchers and IK holders to co-produce knowledge that would be best placed to drive the science curriculum.

Equally, I recommend that teachers' professional development should focus more on the integration of IK. This might in turn guarantee that learners' cultural heritage is always considered a starting point for enriching learning (Kibiringe & van Rooyen, 2006; Mavuru & Ramnarain, 2020). This might ultimately benefit teachers in effectively implementing the integration of IK into the classrooms, resulting in them comfortably considering their learners' diverse socio-cultural backgrounds (Mavuru & Ramnarian, 2017). I also recommend that similar to Mayana's (2020) study conducted in South Africa, learners should be taken out of the science classrooms into the community to learn IK and 'wisdom' from ECMs which could assist them in understanding learning of school science.

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Appendices

Appendix A: Research Ethics clearance



11/06/2020

Prof Kenneth Mlungisi Ngcoza

Email: k.ngcoza@ru.ac.za

Review Reference: 2020-1202-3539

Dear Prof Ngcoza

Re: Revitalisation and indigenisation of the science curriculum through drum making, drumming, music and dance.

Principal Investigator: Prof Kenneth Mlungisi Ngcoza

Collaborators: Mr. Angelius Kanyanga Liveve

This letter confirms that the above research proposal has been reviewed by the Rhodes University Ethical Standards Committee (RUESC) – Human Ethics (HE) subcommittee and PROVISIONALLY APPROVED PENDING GATEKEEPER PERMISSION.

Gatekeeper permission is required from:

a) Kavango West Regional Council, Directorate of Education, Arts and Culture

Once the Gatekeeper permission letter/s has been received please forward it to the Ethics Coordinator, (s.manqele@ru.ac.za) in order to finalize your ethics approval.

Sincerely,

Prof Arthur Webb

Chair: Human Ethics Sub-Committee, RUESC- HE

Appendix B: Permission letter to the Director

The Director

Kavango West Educational Directorate

Kavango West Region

RE: PERMISSION TO CONDUCT EDUCATIONAL RESEARCH IN KAVANGO WEST REGION

Dear Ms. T. Hamutumua

I am Angelius Kanyanga Liveve student no: 15L7775 a doctoral student at Rhodes University, South Africa, conducting research in Kandjimi Circuit. I am writing to ask for your permission to conduct educational research with the three senior secondary school science teachers from three secondary schools, namely Kanuni Haruwodi, Simanya, and Nkuremkuru senior secondary school from the first to the third term of the 2020/2021 academic year. My research provisional title is: *Revitalisation and indigenisation of the science curriculum through drum making, drumming, music, and dance*

. This research is to be conducted with Grade 10 Physics teachers in the Kandjimi Circuit who will voluntarily take part in this research. The research will embark on the topic of fractional distillation. The research aims to benefit Physics teachers in their teaching pedagogy and improve the integration of indigenous knowledge, not only on the concept of sound but in most topics where IK could be useful. Community members will benefit from the research because their local knowledge might be useful in science classrooms and they will advance their interaction and communication with teachers.

There might be minimum risks during phase 3, the phase might have a minimum of four visits to the site (Unongo social-cultural group) in the community since they are the custodian of indigenous knowledge on making drums, drumming, and dance on the participants when the community members will use sharp objects when demonstrating the making of drum and the use of fire during a demonstration on altering of sound tones.

Six Grade 10 Physics teachers from three (3) Schools and a senior education officer for Physics will take part in this study. The research will be divided into five phases. Phase 1: Semi-structured interviews (3 Physics teachers). Phase 2: Workshop: Documents analysis. Phase 3: visit the Unongo social group in the community since they are the custodian of indigenous knowledge on making a drum, drumming, and dances (minimum of four visits). Phase 4: workshop to reflect on the demonstration and explanation received from the community members and to co-develop model lesson on sound phase 5: observe these Grade 10 Physics after being engaged in the co-develop model (Observation & Stimulated Recall Interviews (3 Physics teachers) will be used. I, therefore, seek permission for three secondary schools and six Physics teachers, and senior education officer for Physics to take part in the research after school between 14:00-16:00.

I will assure you that the data generated in this study will not be used for any other purposes outside its intended purpose. However, should a need arise, the information will not be released to a third party without the permission of the Director, Circuit, Schools, and participating Physics teachers. The identity of the region, circuit, schools, and teachers will be treated as confidential and anonymous. The results will be shared with the region after completing the course and workshops will be conducted to help science teachers integrate IK into science lessons.

I would like to assure your office that, should I be granted permission, the research ethics will apply throughout the process of the study. The data collected (hard and soft copies) will be kept in the places that a lockable for 24/7 at least five years. The data collected will be used for reporting in my thesis and publications. Confidentiality of information and anonymity of participants will be guaranteed. Participation in this research is free and the participants are free to withdraw at any time during the research process. The research will be done in the first term of 2020 of the Namibian school calendar.

Nevertheless, this research has been approved by Rhodes University Ethical Standards Committee and the Educational Department Higher Degree Committee to be carried out in Kandjimi Circuit, Kavango West Region as planned.

Your consideration in this regard will be highly appreciated.

Yours Sincerely

AK Liveve (Head of Department at Kaakuwa Combined School and Rhodes University Student)

I can be reached at +264812263019 and email (liveandvero@gmail.com)

NB: For any further inquiries the following can be contacted:

1. My supervisor: Prof K. M. Ngcoza at Rhodes University, email address (k.ngcoza@ru.ac.za), Cell: +27788852143
2. My co-supervisor: Dr. Zukiswa Nhase at Rhodes University, email address (Z.khulane@ru.ac.za or zkhulane@gmail.com), Cell: +27847868093
3. The Rhodes University Ethics Coordinator Research office is Mr. Siyanda Manqele, email address (s.manqele@ru.ac.za), Tell: +27466037727 and Fax: +27866167707

Appendix C: Response from the office of the Director



**KAVANGO WEST REGIONAL COUNCIL
DIRECTORATE EDUCATION, ARTS AND CULTURE**

Tel No: (066) 264976
Email: kavangowestec@yahoo.com
Enquiries: Ms. F. Sikongo
Ref: 26 / 1 / 16

Private Bag 6193, Nkurenkuru
Namibia

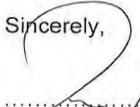
12 June 2020

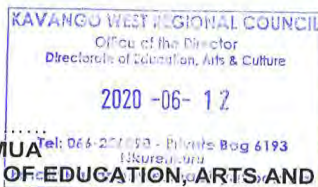
Mr. Angelius K. Liveve
Kaakuwa Combined School
Kavango West Region

**RE: PERMISSION TO CONDUCT RESEARCH AT IDENTIFIED SCHOOLS IN
KAVANGO WEST REGION, KANDJIMI CIRCUIT.**

1. Your letter dated 03 June 2020, which was received on 12 June 2020 on the above subject matter bear references.
2. Permission is granted to conduct research at the identified schools in Kavango West on: **Mobilizing the indigenous practice of drum making, drumming, music and dance to contextualize Grade 10 Physics lessons on the topic of sound**, provided that the activities will not interrupt or negatively affect normal teaching and learning.
3. We wish you well. Should there be any question on the matter, please do not hesitate to contact this office.

Sincerely,


TEOPOLINA HAMUTUMUA
REGIONAL DIRECTOR OF EDUCATION, ARTS AND CULTURE
KAVANGO WEST



12/06/2020
DATE

Appendix D: Permission letter to the knowledgeable community member/s on drum making, drumming, and dance

Mr. X

Village

Mpungu constituency

Kavango West Region

RE: permission to take part in my education research as an indigenous knowledge expert (drum making, drumming, and dance)

Dear Sir/Madam

I am Angelius Kanyanga Liveve student no: 15L7775 a doctoral student at Rhodes University, South Africa, conducting research in Kandjimi Circuit. I am writing to ask for your permission to take part in education research as a participant from the first to the third term of the 2020/2021 academic year. My research provisional title is Revitalisation and indigenisation of the science curriculum through drum making, drumming, music, and dance. The research aims to work with community members to enhance their roles in school as stakeholders.

The research will be divided into five phases. You are kindly requested to demonstrate and explain the processes involved in drum making, drumming, and dance during phase 3 since you are the custodian of this indigenous (minimum of four visits). I, therefore, seek permission to take part in the research after school between 14:00-16:00.

I will assure you that the data generated in this study will not be used for any other purposes outside its intended purpose. However, should a need arise; the information will not be released to a third party without the permission of the participating community member. The identity of the teacher participants will be treated as confidential. Participation in this research is free and the participants are free to withdraw at any time during the research process. The research will be done in the first to the third term of 2020 of the Namibian school calendar

Your identity and that of other participants will be treated as confidential and will remain anonymous.

This research has been approved by both the Rhodes University Ethical Standards Committee and the Education Department Higher Degrees Committee. During the research, any concerns may be directed to Mr. Siyanda Manqele, Ethics Coordinator, Research Office, Rhodes University +27 (0) 46 603 7727, s.manqele@ru.ac.za

Please feel free to contact me at liveandvero@gmail.com or 08061519126 or my supervisor at K.Ngcoza@ru.ac.za and my co-supervisor is Dr. Zukiswa Nhase at Rhodes University, email address (Z.khulane@ru.ac.za or zkhulane@gmail.com), Cell: +27847868093 for further inquiries.

Yours sincerely,

Angelus K Liveve

Declaration

I agree to participate in the research and I understand that I am free to withdraw at any time.

Name:

School:

Signature:

Appendix E: Semi-structured interview schedule

Research topic: Revitalisation and indigenisation of the science curriculum through drum making, drumming, music, and dance

What are Grade 10 Physics teachers' experiences, pedagogical insights, and attitudes toward 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 in teaching Physics?	To find out about their experiences of teaching Physics.
2. Could you please tell me what challenges have you been experiencing when teaching Physics?	To find out the challenges the teachers encounter when teaching the topic of sound with a view of an alternative way of teaching.
3. Could you please tell me what are your views on the integration of local knowledge in Physics lessons?	To find out if teachers are aware of using local knowledge in their Physics 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 of integrating local knowledge in Physics lessons are?	To find out if the teachers understand the value of integrating local knowledge in Physics lessons.
6. Could you please tell me what the disadvantages of integrating local knowledge in Physics lessons are?	To find out if the teachers understand the challenges of integrating local knowledge in Physics lessons.

Appendix F: Teacher's profile

The purpose of this questionnaire is to get the profile of a teacher. The information obtained in this questionnaire will be anonymous and your name will not be used. Please answer all the questions as freely and honestly as you wish.

BIOGRAPHICAL INFORMATION ABOUT TEACHERS AND SCHOOLS

1. Gender

Male	Female

2. Age group (Tick one box)

20 - 25 yrs.	26 – 30	31 – 35	36 - 40	41 – 45	46 – 50	Above 50

3. Qualifications (tick the qualifications you have)

ECP	BETD	ACE/ FDE / MASTEP	BSc	Bed (hons)	MEd	PhD	Other

4. School location where you teach (tick one)

Urban	Rural	Semi-urban	Semi-Rural

5. Teaching Experience in Natural Sciences/Physical Sciences/Life Sciences/Agricultural Science and total teaching experience?

Teaching experience in	Grade	Total teaching experience
Natural Sciences/Physical Science/Life Science, Physics, chemistry and Biology (Choose one by underlining)		

Appendix G: Indicators for teachers' conceptions and dispositions (Atallah et al., 2010, p. 48)

Conceptions	
C1	Describing what they think the subject is—their ideas or thoughts about the integration of local knowledge
C2	Describing what they believe is required to teach the subject
C3	Describing what they believe is required to do the subject (to do the class activities and problems)
C5	Describing what they think is the purpose of integrating local knowledge in the science lessons (why is it included in the school curriculum, its usefulness in everyday life, ...)
C6	Describing what they believe indicates that they are capable to integrate local knowledge science (how do they know that they have learnt from community members' demonstrations and explanations)
Dispositions	
D1	Describing their ability in the teaching of Physics
D2	Describing their attitudes towards the subject
D3	Describing the expectations about the integration of IK in science lessons (what will it help them achieve)
D4	Describing the perceived value of the Physics
D5	Describing the evidence that they would provide to others as a 'proof' that they have learnt how to integrate IK and mediate learning of the co-developed model lessons on the topic of sound in their classrooms after the intervention and as a result of the professional learning community

Appendix H: TSPCK components for transformation of knowledge (adapted from Mavhunga & Rollnick, 2016, pp. 312-313)

CONTENT-SPECIFIC COMPONENTS	INDICATORS
Learner Prior Knowledge (LPK)	What learners already know and include common misconceptions known in a topic.
Curricular Saliency (CS)	<p>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.</p> <p>It also includes the knowledge to logically sequence the learning and the knowledge of pre-concepts needed before teaching a topic.</p>
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 <i>macro</i> , <i>symbol</i> , and <i>sub-microscopic</i> levels that may be employed to support an explanation. Examples are illustrations, metaphors, analogies, models, and stimulations.
Conceptual Teaching Strategies (CTS)	Refers to teaching strategies derived from the considerations made from the other components e.g. (a particular misconception, and particular educational purpose. It excludes general teaching methodologies.

Appendix I: Themes emerging from semi-structured interviews

<i>Research Question: What are Grade 10 Physics teachers' experiences, pedagogical insights, and attitudes toward the use of local or indigenous knowledge in a science lesson?</i>		
Themes	Theory	
	Literature	Conceptual/ Framework Theoretical
Teachers' views towards the use of local knowledge in science lessons.	<p>Reddy (2019).</p> <p>Ogunniyi (2007a, 2004, 1997, 1988).</p>	<p><u>Accommodation</u> refers to how people adapt their ways of thinking to new experiences. Preferably, when their indigenous knowledge clashes with the indigenous knowledge of other <u>cultures</u>.</p> <p>Similarly, when two cultures or systems of thought meet, co-existence can only be found through conceptual <u>appropriation, accommodation, integrative reconciliation, and adaptability.</u></p>
	Le Grange (2019)	Call for a <u>decolonised curriculum</u> . Current textbooks make exclusive

<p>Teachers' understanding of Curriculum and Indigenous Knowledge.</p>	<p>Ogunniyi (2007a)</p>	<p>reference to <u>African indigenous knowledge</u></p> <p>A Science-IKS curriculum that reflects useable images of both systems of thought provides indigenous and non-indigenous learners access to different means of knowing and interpreting experience.</p>
<p>Teaching science by using cultural artifacts</p>	<p>Karlsson, Larsson and Jakobsson (2020); Bhabha (1994)</p>	<p>The adapting of a curriculum so that it meets the cultural needs of the learners is known as <u>cultural translation</u>.</p> <p><u>The capability of translating and transforming scientific content from one national language into another and between every day and academic discourse.</u></p> <p>When two cultures or systems of thought meet, co-existence can only be found through conceptual appropriation, accommodation, integrative reconciliation, and adaptability (Ogunniyi, 2004)</p>

Practical activities in science lessons.	Ting and Tai, (2019); Harman, Cokelez, Dal, and Alper, (2016).	Learners learn <u>by hands-on activities, living, and gaining first-hand concrete</u> experiences. Moreover, to provide support to teachers.
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Appendix J: CoP Adapted from Wenger (2011, p 3)

Problem-solving	Working on a specific proposal and brainstorming ideas about composing new songs
Hunting for information	Attempting to get suitable stem and skin for durable drums
Visit	Link with other communities' projects
Mapping knowledge and identifying gap	Existing knowledge, what the group missing, and what other groups should be connecting with

Appendix K: Themes emerging from semi-structured interviews and discussions during document analysis workshop with cognitive states

Themes	CAT: Cognitive States
Teachers' views towards the use of local knowledge in science lessons.	How do the participants perceive the most prevalent worldview being mobilised to solve the problem in a given context?
Teachers' understanding of Curriculum and Indigenous Knowledge.	The participants identify a worldview that is passive to the more dominant one. Similarly, how curriculum obliges teachers to put WKS ahead of IKS
Teaching science using cultural artifacts	The participants draw ideas assimilated into another more adaptable conception. The worldview that develops from a new experience e.g., the acquisition of a new concept in a science class.
Teacher and practical activities in sciences.	Participants able to see competing ideas tend to co-exist in both Grade 10 Physics teachers as an emotional arousal experience.

Appendix L: Teachers' views toward the use of indigenous knowledge in science lessons

The use of local or indigenous knowledge in science lessons	
Mburu	<ul style="list-style-type: none"> • In both Physics and Chemistry, when learners go home think there is no science and; • When teacher link what learners' study in the class or the content in class with the real-life application outside it make it more meaningful and it gets intuited in their minds (S-SI)
Lyako	<ul style="list-style-type: none"> • Some learners may locally have an idea, but when they come to class they have been blocked because they come with something but cannot prove it; • Many teachers only concentrate on a Western or scientific way of knowing things, but if we could give both teachers and learners a platform to express themselves in a language that they understand and can elaborate on more it could also help us to improve our Physical science in a local way (S-SI).
	<ul style="list-style-type: none"> • There are few physical scientific approaches where there are measurements and density, for example; • When a person wants to cross a river using a canoe and you have to measure how it floats (GD).
Nda-kulanda	<ul style="list-style-type: none"> • I realised that integration of local knowledge is very content; • Teachers look at learners' backgrounds and bring them all for a better understanding of both (village and town) (S-SI).
	<ul style="list-style-type: none"> • Yes, there is absolutely a big benefit for them because it's like you are acknowledging the knowledge that a learner comes with from home (GD)
Kambinda	<ul style="list-style-type: none"> • Integrating local knowledge empowers and acknowledges the learners' prior knowledge and; • It's relaxed for learners to perform better (S-SI)

	<ul style="list-style-type: none"> • Learners see the surroundings and know the environment well and; • Clear doubt of learners that may conclude that indigenous knowledge or what is learnt from home is wrong since the teacher taught it differently (GD).
Kondjereni	<ul style="list-style-type: none"> • Yes, it is possible where teachers to understand what it means is very possible; • Where in my case, “I always bring any knowledge from the local environment” and; • Teaching should integrate with learners' experiences be it from the previous school, classroom, or home (S-SI & GD).
	<ul style="list-style-type: none"> • It is very useful in science practices since it helps both teachers and learners to understand the science behind their cultural practices and; • Help them to relate with the science in the curriculum and/or textbooks in elucidating science vocabularies or concepts (GD).
Kaurungi	<ul style="list-style-type: none"> • Learners find it more useful and fun and learn smoothly; • IK is used only in certain topics like distillation, friction, force and weight, sound, light, etc (GD).
	<ul style="list-style-type: none"> • It could enhance their understanding even if the topic was more obstructing for them to understand (S-SI & GD).

Appendix M: Teachers' understanding of curriculum and indigenous knowledge

Physics Teacher	Teachers' understanding of Curriculum and indigenous knowledge	Research Tool(s)
Mburu	The curriculum does not provide sufficient IK and direction on how teachers can use them in their lessons	S-SI
Kondjereni	No point in the curriculum informing teachers of the use of indigenous knowledge	GD
Kaurungi	Textbooks show little IK and only a few pictures from the localities	
Nda-Kulanda	The curriculum for higher education does not implement IK when teachers are trained, so teachers find it difficult to implement it into their lessons	S-SI
Lyako	The practical investigation would go smooth with the integration of IK, but teachers lack with a conference where they are informed on how to intergraded IK	S-SI & GD
Kambinda	IK is not legitimate even if teachers attempt to integrate this knowledge the assessment is established on Western science	

Appendix N: Teaching science using cultural artefacts

Teaching science using cultural artefacts	
Kambinda	The approaches that provide promise and possibility for engaging lessened learners in the activities of science

Kaurungi	This method suggests specific instructional styles over the use of IK practices in both resourced and under-resourced schools
Lyako	About how a community uses tools that exist in a given culture or society for thinking and acting
Kondjereni	This is the realistic prior knowledge that a teacher can use in smoothly the learning and teaching process
Nda-Kulanda	When teachers embrace the science reflected in cultural structures
Mburu	The school could visit the site where the community member is applying science or the teacher could bring the artifacts used in the community into the classroom

Appendix O: Cultural practices which could support teaching and learning of science concepts

Exploring other IK in teachers other science concepts (Chemistry and Physics)

Physics Teacher	Some proposed cultural practices reflect science	In which concepts can be engaged?
Lyako	Beer making- <i>kudunga and kukendja</i>	Fermentation and Distillation
	African furnace (<i>Mudukuto in Rukwangali and Muvanje in (NyembaMashaka)</i>) is used for processing metals.	Properties of metal: malleability
	Extraction of oil from Mahokwa- <i>mangeti</i> seeds.	Separation of mixtures, density, etc
	Fire making- <i>kudiga</i>	Force: friction
Mburu	Thrashing and/or pounding (sieving)	Method of separating mixtures, energy conversation
	Home tanning (uses of ashes)	Acid, bases, and alkaline Raw materials
	Not standing next to animal example; dogs, cattle and also not standing under a tree to avoid lightning	Conduction
Kaurungi	Using calabash and clay pot in cooling water or drinks	Cooling and latent heat of evaporation
	Chopping of firewood	Source of energy, increasing the rate of reaction: size and surface area
	Preparation of traditional drinks (non-alcoholic and alcoholic drinks- <i>Sikundu and mutoho, mundevere etc</i>)	Fermentation

	The uses of animal dung (<i>Erombo or ruhoho</i>)	Biomass
Nda-Kulanda	Getting wild lemon from its tree	Force of gravity
	Traditional dances during cultural concerts: weddings and transitions	Sound and waves
	Healing by steaming	Change of phases (states of matter)
	Healing a wound by casting powder	Absorption
Kambinda	Winnowing of millet	Separation of mixture: sorting
	Fetching water from well- <i>ndjombo</i>	Mechanics- pulley
	Churning fermented milk	Fermentation, and even for the teaching of the pendulum
	Thatching	Properties of materials: insulation
Kondjereni	Salting, drying, and smoking	Processing and preserving of food
	Knitting	Materials

Appendix P: Teachers' responses regarding practical activities in science lessons

Practical activities in sciences lessons

Mburu	Supporting the teaching of scientific knowledge, and teaching the processes of scientific investigation (DA).
Kaurungi	Encouraging learners to be innovative and creative (S-SI & GD)
Nda-Kulnda	Enable learners to see the unseen refers to a more 'abstract' (S-SI)
Kondjereni	Are effective in enabling the majority of learners to do what the teacher intended with the objects provided – that is, successfully 'produce the phenomenon' (S-SI & GD).
Kambinda	Ensure many science teachers believe that learner practical work leads to better learning since all understand and remember things better if have done it themselves (S-SI & GD).
Lyako	Learners can learn new ideas by being shown examples of them, rather than being given formal definitions, or other verbal accounts (S-SI & GD).

Appendix Q: Five cognitive states of CAT (Ogunniyi 2007a)

The nature of the teachers' perceptual shifts relative to mobilising Indigenous Practice during document analysis Workshop 2

Concepts	Western Knowledge Systems (WKS)		Indigenous Knowledge Systems (IKS)	
Scientific skill	Dominants	Most adaptable knowledge	Assimilated	Regarded as passive by WKS
Sound	Dominants	More Eurocentric	Emergent	New ideas have been gained in a science class
Mechanics	Dominants	Most relevant in all assessment	Suppressed	More inferior to the WSK
Separating mixtures	Assimilated	Passive, because participants considered that sorting, filtration, decanting, distillation, etc are commonly done locally	Suppressed	Participants were able to identify those passives in the context of IK integration
Force: weight and Friction	Equipollent	Participants were able to see the competing ideas tend to co-exist in the curriculum	Equipollent	Through the explanation by the facilitator, teachers were able to exert equal cognitive force on the community's worldview
Convection: energy wave Chemical change exothermic reaction	Dominants	The participants notice the most prevalent worldview being equipped to solve the problem in a given context	Suppressed	The curriculum is obligatory to the teachers in putting WKS ahead of IKS
Biodegradable	Equipollent	The concept tends to co-exist in their teaching set up	Assimilated	The participant realises the concepts assimilated into another more adaptable outset

States matter	of Dominants	More Eurocentric, although practices are more likely found in their mediated communities.	Suppressed	The presence of artefacts in the community is also a disclosure that members of the community use science even though they might be unaware of specific science concepts.
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Appendix R: Temperature record for the participants during workshops in phase 2

Grade 10 Physics teachers' temperature in °C					Community members' temperature in °C				
Teacher	W1 28	W2	W3	W4	MC29 used clan names of their family	W1	W2	W3	W4
Researcher	35.5	36.4	36.0	36.4	Tate Matia	36.2	37.0	36.4	36.4
Kaurungi	36.8	36.3	36.2	35.7	Onane Mukwanzadi	36.3	36.7	36.6	36.0
Mburu	36.3	35.4	36.5	35.8	Otate Mukwasipika	35.8	36.3	36.2	36.6
Lyako	36.2	34.5	35.7	36.0	Otate Mukwangombe	37.0	35.8	36.5	36.8
Nda_Kulanda	35.8	36.8	36.1	36.1	Onane Mukwanyatji	36.6	37.0	37.2	36.8
Kondjereni	36.4	35.7	35.6	35.8	Otate Mukwanzovhu	35.8	36.6	36.5	36.7
Kambinda	36.5	36.0	37.1	36.2	Onane Mukwankora	36.8	37.0	36.3	36.7
					Onane Mukwanyime	36.6	36.8	37.0	36.5
					Onane Mukwambahu	35.8	35.9	36.4	36.5
					Onane Mukwanangandu	36.0	37.0	36.7	35.8

28 W in this table represents workshop [W1-4) and workshop 1 was for orientation, mainly to know each other and build trust among participants]

29 CM stands for community member

Appendix S: Traditional music instruments

Different types of traditional instruments found in the local environment			
Instrument	Source of materials	Common tribe	Status
Drums	Goat and calf skins	Both Vakwangali and Vanyemba	Active
Rattle	Calabash and seeds, wild lemon shell and seeds or horn and maize grains	Vanyemba	Active
Sticks- <i>Milyangu</i> in Nyemba language	Natural sticks	Vanyemba	Inactive
Horns- <i>Thzindumbu</i>	Goat and cow horns	Vanyemba	Inactive

Appendix T: Traditional dances in the local community

Some types of traditional dances found in the local environment			
Dance	Purpose	Instruments involved	season
<i>Epera</i>	Wedding, coronation, crop harvest, and other ceremonies	Drums and hand clapping accompanied by ululating	Any season
<i>Ukambe</i>	Hunting	Combo of three drums and rattles	Before and after hunting
<i>Unyanga</i>	Healing- <i>mahamba</i>	Three drums and rattles	Any season
<i>Makopo</i>	Wedding, welcoming family member, harvesting, coronation, birthday celebration	Three drums	Any time of the season
<i>Matusu and kazambi</i>	Healing	Three drums	Spring

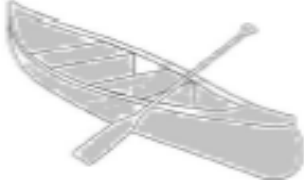
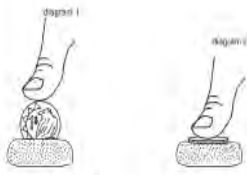
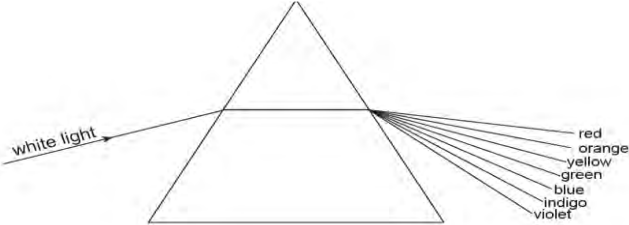
<i>Makisi (Tungandzi)</i>	Welcoming boys from <i>mukanda-vamba</i> camp	Three to four drums, sticks, and rattle	Winter
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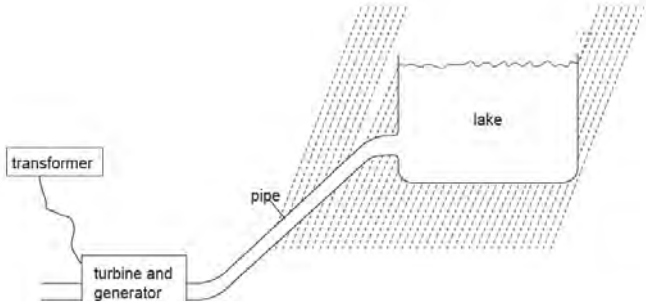
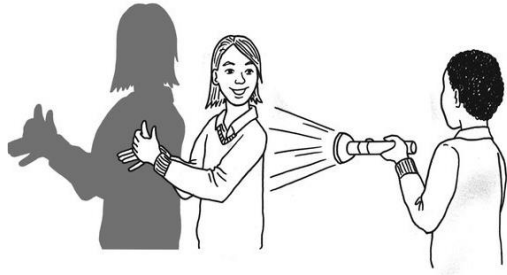
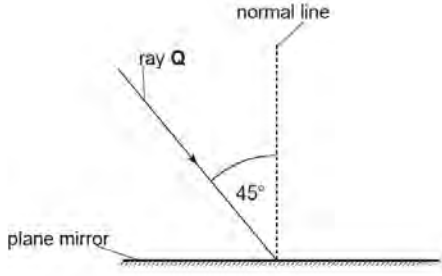
Appendix U: Scheme of assessment for grade 10 and 11

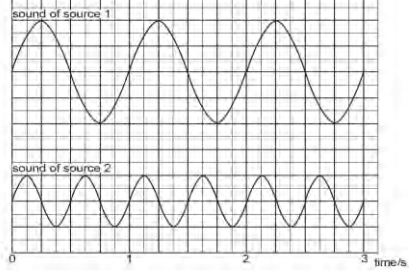
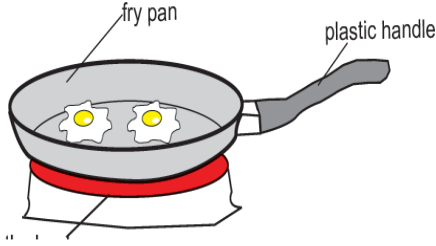
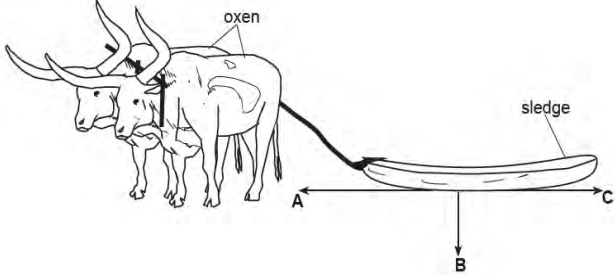
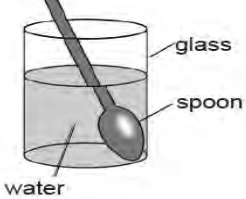
All learners should be entered for Paper 1.2 and 3 which are compulsory papers			
Paper	Description of paper and types of questions	Duration of paper	Marks
Paper 1: Theory: Multiple-choice question	This paper entails forty multiple-choice items of the four-choice type. The questions will be based on the content described in the specific objectives and will test abilities in assessment objectives A and B. learners should attempt all questions	45 minutes	40
Paper 2: Theory: Structured questions	This paper requires compulsory short-answer, structured and free-response questions. The questions will test skills and abilities in assessment objectives A and B	1 hour 15 minutes	80
Paper 3: Alternative to practical: assessment of practical skills and abilities	This paper is a written paper of compulsory questions designed to test familiarity with practical laboratory procedures and will test skills in assessment objective C. learners must be exposed to practical work and demonstrations	1 hour 15 minutes	40
Total			160

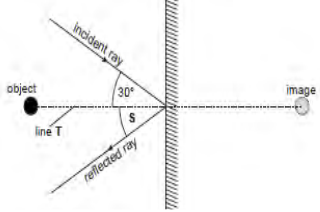
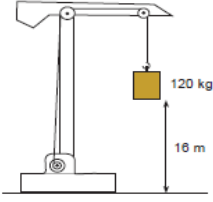
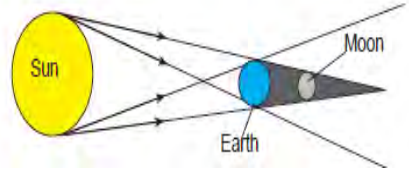
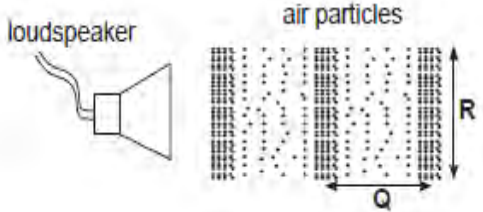
Source: NSSCO Physics Syllabus (NIED, 2018, p. 38)

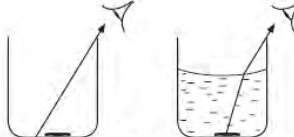
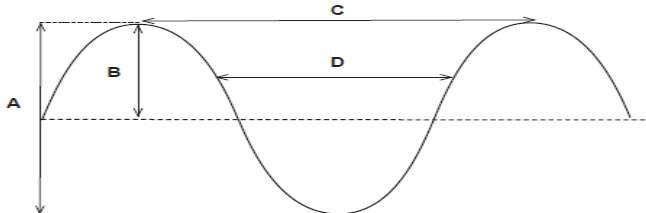
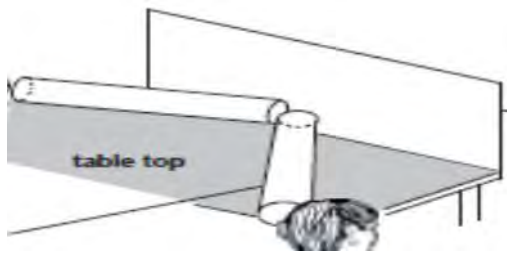
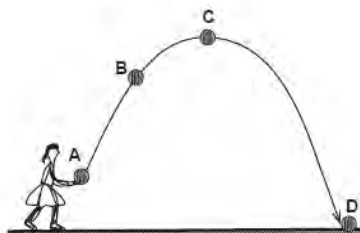
Appendix V: Grade 10 Physics teachers' analysis of past exam papers about IK during co-developed exemplar lessons

Topic in the past examination paper that reveal cultural knowledge		
Academic year	Topic(s)	Cultural practices/ everyday life experiences
2019	Density- floating	Canoe floats in the river 
	Pressure exerted	Using the same force, the coin pressed on the edge and then on its flat surface 
2017	Refraction of light	The colours of the spectrum 

	<p>Form of energy</p>	<p>Energy conversion</p>  <p>The diagram illustrates a hydroelectric power system. It features a transformer connected to a turbine and generator. A pipe leads from the turbine and generator to a lake. The lake is situated at a higher elevation than the turbine and generator, and the pipe is inclined upwards. The lake is surrounded by a hatched area representing a dam or reservoir.</p>
<p>2016</p>	<p>The basic concept of light</p>	<p>The property of light as it travels in a straight line hence shadow to form</p>  <p>The diagram shows a person on the right holding a flashlight, shining it towards a person on the left. The person on the left is standing in front of a wall, and a shadow of their hand and arm is cast onto the wall. This illustrates the property of light traveling in straight lines.</p>
	<p>Reflection of light</p>	<p>Light rays striking a plane mirror</p>  <p>The diagram shows a light ray labeled 'ray Q' striking a horizontal plane mirror. A vertical dashed line perpendicular to the mirror is labeled 'normal line'. The angle between the incident ray and the normal line is marked as 45 degrees.</p>
<p>2015</p>	<p>A general property of sound</p>	<p>Property of sound waves</p>

		
	<p>Convection</p>	<p>Transfer of thermal energy</p> 
<p>2014</p>	<p>Form of energy: Kinetic energy</p>	<p>A moving sledge</p> 
	<p>Refraction of light</p>	<p>A spoon immersed in a glass of water appears bent</p> 
<p>2013</p>	<p>Property of light</p>	<p>Reflection of light</p>

		
	<p>Work and energy</p>	<p>Crane lifting a 120 kg block of concrete</p> 
<p>2011</p>	<p>Property of light: The formation of shadow</p>	<p>The arrangement of the sun, earth, and moon during a lunar eclipse</p> 
	<p>Sound waves: Longitudinal waves</p>	<p>Sound waves from a loudspeaker travel through the air</p> 
<p>2010</p>	<p>Refraction of light</p>	<p>Learners can see the coin from the same position as shown below</p>

		 <p>coin invisible from a certain position above the an empty beaker</p> <p>coin visible from the same position after water is poured into the beaker</p>
	<p>Sound properties</p>	<p>Shows a wave pattern</p> 
<p>2007</p>	<p>Sound waves: Reflection of sound</p>	<p>Drumming, music, and dance: echo activity</p> 
	<p>Conversion of energy</p>	<p>Show the position is the gravitational (potential) energy of the ball the greatest</p> 

Properties of materials:
Building materials

Building material



Appendix W: Summary of the observed topics and indigenous technologies

Indigenous knowledge is involved when teaching the identified concepts		
	TOPIC	INDIGENOUS KNOWLEDGE
Kaurungi	The basic concepts of light	Lightning and Thunder as well as observing a man cutting down a tree from a distance and tracing shadow activity
	Convection	Sitting around the fire, Ironing a skirt and hot burner on the stove into a pot
Lyako	Refraction of light	Prism-Rainbows, Fishing by using arrow and bowl, (Thirsty traveller) Mirages, Bent splint in the glass of water, and Hosepipe activity
	Forms of energy	Pendulums, Bow & Arrow, and slingshot ³⁰ - <i>Ngumi</i>
Nda-Kulanda	General wave properties	Drumming, Hosepipe /rope activity, and turning fork
	Reflection of sound	Folklore and echo activities

³⁰ Object made up of a piece of skin attached to rubber band (as illustrated in Figure 8.19-8.21). It was used to throw stones at a tangent after a circular motion.

Appendix X: Analytical framework for CAT

Five cognitive States of CAT (Ogunniyi,2007)		
Physics Teachers (Kaurung, Mburu & Lyako)		
Cognitive state		
OL	Dominant	Suppressed
1	Learners notice the most predominant worldview being equipped to solve the problem.	Learners were obliged to align WKS and IKS.
2	Dispersal of light is more scientific. Learners were not having an idea that rainbow is the effect of refractions of the main seven colours	Learners believed that the rainbow is a huge snake and it has higher both cultural and religious beliefs. More in customary
OL	Assimilated	Emergent
1	Learners realise that convection is more espoused in their immediate societies. Boiling water, sitting around the fire while listening to stories and why is colder in the lower elevations in the valley than in the higher ones.	Learners were able to develop their Physics concepts, in which the whole medium moves and carries heat energy with it.
2	The Grade 10 Physics learners managed to adopt the scientifically meaning and formation of the rainbow. Rainbow activities were espoused in their immediate environments	Realise that, rainbows are made up of all seven colours that come from light. Rod does not bend, the only light that deflects when entering or leaving the medium hence, the speed changes.
OL	Equipollent	

1	Learners directed both WKS and IKS in an equal length, and complement one another in the learning of Physics
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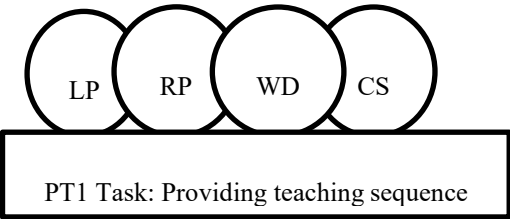
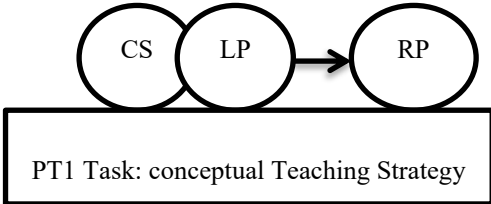
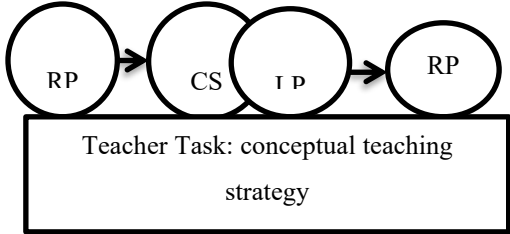
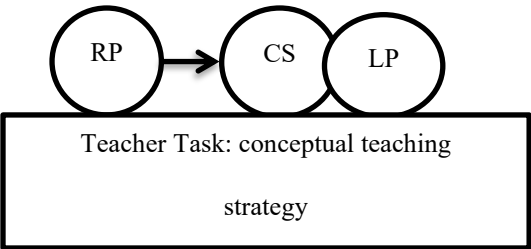
Appendix Y: TSPCK of the analytical framework (adapted from Mavhunga & Rollnick, 2017)

Kaurungi, Mburu components for the transformation of knowledge in their lessons			
COMPONENTS	CONDITIONS	REMARKS (Kaurungi, Mburu & Lyako)	
		Kaurungi: (OL1& OL2)	Mburu: OL1 & OL2
Learners Prior Knowledge (LPK)	What learners already know and the common misconceptions involved in the topic	<ul style="list-style-type: none"> • Visual • Diagram • Picture • Role-play • Asked learners' experiences about the topic 	<ul style="list-style-type: none"> • Drawing • Graphics
Curricular Saliency (CS)	Based on the identification of the most important meaning of the major concepts in the topic and also includes the knowledge to logically order the learning and skills of the pre-concepts that requires before teaching the topic.	<ul style="list-style-type: none"> • Comprehensive for what to use to explain convection and refraction of light • Connect the daily application of both convection and refraction of light 	The content was taught by demonstration and explanations
What is Difficult to Understand (WDU)	Matters considered difficult to learn, the teacher needs to identify actual issues that make understanding difficult. The focus was on the pinpointing the actual difficulty due to less connection to the previously learnt content	<ul style="list-style-type: none"> • Gave clear instructions • Use analogies • Questions and answer • Engage all learners in the discussion 	The teacher defined and explained the concepts

Representations (RP)	Uses of visuals, analogies, and symbols that may be applied to support the teachers' explanations	<ul style="list-style-type: none"> • Analogies • Graphics • Simulations 	<ul style="list-style-type: none"> • Analogies • Models • Drawings
Conceptual Teaching Strategies (CTS)	Involves the teaching approaches, for instance, introduction content, centred lesson presentation, and conclusion	Allow learners explained their work/ diagrams (See Fig 8.11). Motivate their conclusions	<ul style="list-style-type: none"> • Activities' reflection • Group report
Lyako components for the transformation of knowledge			
Components	CONDITIONS	Lyako	
Learners' Prior Knowledge (LPK)	What learners already know and the common misconceptions involved in the topic	Begin with storytelling and follow a question on a common learner misconception, whether the echo is the reflection of sound. This activity was a whole class discussion with probing questions	
Curricular Saliency (CS)	Based on the identification of the most important meaning of the major concepts in the topic and also includes the knowledge to logically order the learning and skills of the pre-concepts that requires before teaching the topic.	Assemble the concept maps such that the suggested major ideas are in sequence, showing prior concepts and linked to subordinate concepts with explanatory notes.	
What is Difficult to Understand (WDU)	Matters considered difficult to learn, the teacher needs to identify actual issues that make understanding difficult. The focus was on the pinpointing the actual difficulty due to less connection to the previously learnt content	In the same groups, participating learners were asked to share their experiences as and from their communities during the cultural experience, what they considered difficult for learners to understand, and, in turn, what teachers found difficult to transform.	

<p>Representations (RP)</p>	<p>Uses of visuals, analogies, and symbols that may be applied to support the teachers' explanations</p>	<p>The teacher uses an analogy to demonstrate compression and rarefaction. Also, drawings, pictures, and video clips were used to support the explanations</p>
<p>Conceptual Teaching Strategies (CTS)</p>	<p>Involves the teaching approach introduction content, centre lesson presentation, and conclusion</p>	<p>Practiced to develop lessons plans showing deliberate consideration of the knowledge consolidated with the other four TSPCK components</p>

Appendix Z: Sample TSPCK MAPs for observed developed TSPCK component interactions (Adapted from Mavhunga, 2020)

Participant	TSPCK Sequence		TSPCK MAP	Nature of teacher task
Kaurungi	OL1	LP/RP/WD/CS		Summary of the most important CK in a lesson
	OL2	CS/LP-RP		Teaching sequence in a lesson
Mburu	OL1	RP-CS/LP-RP		Conceptual Teaching strategy
	OL2	CS-CTS/LP		Teaching sequence in a lesson

Lyako	OL	RP-CS/LP-RP		Summary of most essential CK in a lesson
		CS/RP-WD/LP-CTS		Teaching sequence in a lesson

Appendix AA: Statement Agreement for Mr. Neporo to use his real name

TITLE OF STUDY: Revitalization and indigenization of the science curriculum through drum making, drumming, music and dance

PRINCIPAL INVESTIGATOR: ANGELIUS KANYANGA LIVEVE

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Cell: +264812263019

Education Department

Rhodes University]

Principal Supervisor: Prof. Kenneth M. Ngezoa

Co-supervisor: Dr. Zukiswa Kuhlana

PURPOSE OF STUDY

This study sought to contribute to social justice by exploring how to mobilize the indigenous technology of *drum making, drumming, music and dance* for cultural revitalization and indigenisation of the science curriculum.

Statement of agreement

I, Mr Johannes Neporo a research participant for Mr A. Liveve's study here by grant him permission to use my real name **NEPORO** in his thesis I fully understand the ethical issues as per University requirement.



Johannes Neporo
Research participant



Date

Angelius K Liveve
Researcher

Date

Appendix BB: Collated semi-structured interview data

What are Grade 10 Physics teachers' experiences, pedagogical insights, and attitudes toward the use of local indigenous knowledge in science teaching?

Collate interviews with seven Grade 10 Physics teachers

Key:	IK	Challenge to integrate	Practical activities	Cultural heritage
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Questions	Neporo	Kaurun gi	Nda-Kulanda	Mburu	Lyako	Kondjere ni	Kambinda
Could you please tell me about your experience in teaching Physics?	Alright, I have been teaching Physical science for the past 10 years. I enjoy teaching science subjects. Back in high school, I was good at the science subject. I use to get an award which is	From the learners' point of view, many learners enjoy practical activities because they see some of these things in their real lives. Currently, now I'm teaching senior secondary	I started teaching in 2010 so I have 9 years of teaching experience. The first school where I taught is Yinsu combined School from Grade 5-7 Natural Science and mathematics and Physical Science grade 8.	Teaching Physical science has been an interesting journey because it comprised both Physics and Chemistry and for the past years that I have been teaching at a different level I learnt a different	Since I have been teaching for the past 10 years, for the assessment part I enjoy the practical activities.	I have been teaching that in Physical science they are topics for chemistry and Physics a great journey. But, still, some learners at some schools find it easier and others still	Initial, at the onset of my teaching profession I was supposed to start teaching from Grade 4-to 7. But to the school where I was asked to teach from Grade 8-10 because I was the only one who was

	<p>the reason that forced me to become a Physical science teacher.</p>	<p>y which is Grade 11-12 for the old curriculum, and physical science grade 8-10, and the new one which is chemistry. The new curriculum started this year for the senior phase (Grade 10), but I am also still teaching the old one for Grade 11 which will lapse next year. Teaching</p>		<p>understanding of how learners from different schools understand the different topics it is not a difficult subject but many views it as an obstacle subject.</p> <p>I have been teaching Physical science because in the previous curriculum it was Physical science up to Grade 10.</p>		<p>struggle with the subject content. Eh, the year “2020” is the first time for the Grade 10 to do Physics and Chemistry separately which are the phases that I am not teaching.</p>	<p>qualified at least, then from there, I had to move from one school to another at certain points I was attached to a volunteer. Who training me how to teach Grade 11-12, because the school I taught by that time was upgraded to Grade 12, and I was again the only one so I have to be uplifted to someone train me we use to do co-teaching</p>
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		<p>science is a bit challenging but I enjoy it being one of the females teaching it as most of the learners fear that it is difficult. I also feel that I am inspiring female learners as they believe that it is only for boys and most of them do not perform well in science. If you put more effort,</p>				<p>until at the end I could teach at my own.</p>
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		<p>you receive good results, for the past years I have been producing good results and now I obtained 50% of which I am proud of</p>					
<p>Could you please tell me what challenges have you been experiencing when teaching Physics?</p>	<p>Yeah, some challenges, especially female learners seeing science as a male dominant subject and visualise it as a male</p>	<p>Due to the lack of role models, when it comes to women and science subjects it becomes difficult to make them understand</p>	<p>Thanks for the flow given to me, I have 14 years of teaching experience in Physical science, and one of the stumbling blocks which I experienced in teaching Physical science is that learners or our</p>	<p>Although, the school is an urban school that is under resources when it comes to science-oriented equipment, apparatus, and chemicals. Although</p>	<p>Some of the encountered challenges during the teaching of Physical science is a lack of teaching and learning resources whereby five learners can share one textbook only the strongest/hardw</p>	<p>The only challenge we have been experiencing is teaching aids, some schools are well equipped with the modern teaching facilities whereas at</p>	<p>The challenge is that some might misinterpret and miss the theoretical part of it. We have learners from various backgrounds but you have to</p>

<p>subject, maybe because they see in really live that most engineers and scientists are all males.</p> <p>Mainly, these are some of the major two challenge s; the first one is that female learner are not so much into science and the second challenge is the lack of apparatus , equipmen t, and chemicals to carry</p>	<p>nd. For instance, in one of the classes I teach, there are 40 learners and only four of them are females. So, their mindset should be changed for them to realise that science is for everyone .</p> <p>There are numerou s challeng es when teaching science. Among other challeng es are</p>	<p>kids have an interest in learning, but the problem is a lack of resources like textbooks, labs, etc. whereby sometimes you will find that it's only the teacher who has a textbook and learners has to share.</p>	<p>sometimes I tried to improvise, sometimes certain things teachers cannot improvise; need to use the right thing. If you improvise, you end up not teaching the correct content you want to convey.</p>	<p>orking or serious ones can benefit well, which disturbs learners so much.</p>	<p>the current school we do not even have a lab but other schools do have one in case, there are no teaching resources at the same time very difficult to administer because you expect learners to do practical and then they write the exam.</p>	<p>bring them all in for a better understanding. For example; methods of separating mixture (filtration and distillation) water mixed with dead and small living things, like water collected from pans and streams.</p>
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	<p>out the experiments. science is everything we do, no matter what</p>	<p>equipment, apparatus, and chemical stuff.</p>					
<p>Could you please tell me what are your views on the integration of local knowledge in Physics lessons?</p>	<p>In terms of IK and WS integrations, most of these learners are from Oshiwambo native or cultural backgrounds. When it comes to certain topics like in science, previously it was the combination of chemistry</p>	<p>The lesson for integrating drums into the topic of sound would be an interesting one because most of the learners like traditional music and dancing. This will motivate them to also</p>	<p>Some learners may locally have an idea, but when they come to class they have been blocked because they come with something but cannot prove it, just want to concentrate on a Western or scientific way of knowing things, but if we could give them a platform to express themselves in a language which they understand</p>	<p>It is difficult to say because once you use the word 'IK' I thought of the investigation knowledge in the science classroom. Integration promotes learners' thinking but, it must handle effectively</p>	<p>The lack of proper apparatus and science laboratories is a big challenge for experiments and practicals. The classroom setup is not suitable for experiments and there is overcrowding in classes whereby learners do less than teachers in both Junior and Senior Secondary. Learners do well by seeing. I realised that the integration of local knowledge is very happy.</p>	<p>Yes, teachers may understand what it means is very possible. Where in my case I always bring any knowledge from the local environment. I integrated my teaching with learners' experience so be it from the</p>	<p>It is always vital to be extra careful when linking indigenous knowledge to classroom situations, not preferring one over the other one. Teachers should also familiarise themselves well with the topic before delivering the</p>

	<p>and Physics.</p>	<p>participate in the lesson.</p> <p>In Western countries which are developed and rich learners can perform better from a lower Grade to universities</p> <p>because they do it in a local way (vernacular language).</p> <p>With us, the main stumbling block is the</p>	<p>and can elaborate more it could also help us to improve our Physical science locally.</p>			<p>previous school, in the classroom, or from home. That is what I use to do. However, I was not taught how I can use it either at the college or during workshops</p>	<p>information to learners to avoid confusion. Learners' backgrounds should also be well considered to incorporate them all (rural areas and towns) to balance the situation.</p> <p>Whenever introducing the topic starts with the indigenous knowledge, it helps learners to have an idea of what you have about to talk about and they will try to link</p>
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		language barrier					<p>it, so this way it can help them to understand it better rather than purely new information.</p> <p>Examiner's examples. But learners could not agree that the rainbow is not an animal but a mixture of different colours</p>
<p>Could you please give me an example of any topic in which you think you can integrate</p>	<p>Currently in the context of Grade 10 science is split into two namely Physics and</p>	<p>Let us say, you are a teaching mechanic. I normally, talked about, because</p>	<p>Putting a cloth in between the head and an object to avoid the body contact and for the support of the carried object which is a hot or</p>	<p>The only I can say is that we see how indigenous knowledge uses science and it</p>	<p>When talking about building materials for roofing in Physical science like zincs and grass an examiner may put a hut or zinced one and</p>	<p>Drums are some of the well-known musical instruments, there are three types of drums used in</p>	<p>There is science in cultural music and studying sound using musical instruments makes it</p>

<p>local knowledge?</p>	<p>Chemistry. Moreover, chemistry topics such as separating techniques are the most topic, I improvise instead of using a beaker, filter paper, and funnel, I use a jar (a bottle of mayonnaise) to replace a beaker. Filter paper, I use an old cloth while a funnel I cut a 2 liters cool</p>	<p>most of my learners come from inland (villages) where there is a very rare amount of water, people have to dig water from the ground, so, they normally use a bucket tied on two poles, on with rope and lower it in a deep hole to collect water. So that one is like a pulling system to make</p>	<p>heavy object to neutralize or not cause an effect on the head (this is called straw to separate the surface) to avoid friction or pressure. It also enables learners to remember it as the knowledge and materials used are within the community/society because they see and touch it.</p> <p>Drawing from practical work and/or activities is the key. sometimes I use it outside the classroom to explore and engage learners when carrying out investigating</p>	<p>helps us understand the science today. Science practical activities may therefore involve illustrations of a phenomenon, providing experiences or getting a feel for the phenomenon by learners, exercises or routines for learners to follow, developing a particular skill, or becoming used to a piece of</p>	<p>learners can be asked what type of materials are used on a hut and what type of roofing is used on a corrugated iron house. He/she may also ask about the advantages and disadvantages of these types of roofing. When setting question papers, they can be divided, for example, if the examiner asks about a traditional house (hut) in this year's question paper, then the following year they will ask about a zinced house. So, when examiners ask questions, they know already that teachers talked or taught about both urban and rural areas' roofing materials</p>	<p>cultural performances. The smallest, middle, and the big or main ones give a bass sound. The only thing about the sound is that it depends on how the drum is made, the sound it gives, and how the person operates it depending on the type of dance performed at that specific time. The reason why the main one sounds different is</p>	<p>more interesting to teach about the sound wave.</p>
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<p>drink to get the top part to be in the form of a funnel when separating Oshikundu and even mud water to obtain a residue for them to look clean although not pure. I assure you that I did not learn this during my college training.</p>	<p>work easier. They do that at home and they realised that is not strange. But I have no idea of how to integrate this knowledge called local/indigenous us</p>	<p>activities. I use models, pictures, and others to strengthen my teaching.</p>	<p>equipment or instrument IK integration develops learners' thinking and knowledge. But I was not trained</p>	<p>to be used when constructing a house. Meaning all learners who are in town and rural areas are going to benefit as the situation is balanced for all levels to know or learn about various types of roofing materials.</p>	<p>that there is normally a black staff like honey which they use to apply on it, unlike the other two drums. The drums almost give the same sound but depending on how they are operated. The cultural instrument can fall in Physics under the topic of sound because when you talk about the sound it's like you are referring</p>
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						<p>to amplitude and pitch.</p> <p>So, the topic can be amplitude and loudness (production of sound), which is the amount of energy applied to produce sound and vibration.</p>	
<p>Could you please tell me what the advantages of integrating local knowledge in Physics lessons are?</p>	<p>Particularly, the sound production 'how is sound made?' teacher obviously call in the choir expert or someone</p>	<p>It's very important for learners to be exposed to their everyday experiences and for a teacher to link</p>	<p>Physics mostly does with energy and matter. For instance, water wave, teaching the concept of wave, and teaching-learning from the textbook which is a</p>	<p>Science practical activities may therefore involve illustrations of a phenomenon providing experiences or</p>	<p>In this regard, the sound is science and all sound no matter what sound it makes has scientific principles.</p> <p>Learning by integrating indigenous</p>	<p>There are a lot of things that the present science does not know about and each day we discover new.</p>	<p>Yes, there is absolutely a big benefit for them because it's like you are acknowledging the knowledge that a learner</p>

<p>to sell them about playing a guitar or drum cause a string or hide to vibrate as it produces sound. Learners have perception that science stops inside the classroom. In both Physics and Chemistry, when learners go home think there is no science. When a teacher links the content in</p>	<p>learners 'everyday experiences to lessons in the classroom. Because it arouses their interest and pay attention during lessons, which encourages them to think critically about the thing that surrounds them.</p>	<p>secondary source. Better to teach learners from the primary source, throwing a ball in water and they see how to move and/or floating objects. In the content of sound waves, situational most of the learners are more musical oriented. Asking learners how to filter them from water and they respond by saying "you take a cloth or your grandmother's scarf which is called filtration". We talk about distillation when brewing</p>	<p>getting a feel for the phenomenon on by learners, exercises or routines for learners to follow, developing a particular skill, or becoming used to a piece of equipment or instrument</p>	<p>technologies and Westernised science aided teachers' insights. It showed them that Physics learning can be enriched by an interconnected system of worldviews to find solutions to challenges regarding IK integration</p>	<p>comes with from home. Some of the learners don't succeed in school to complete or further their studies, but if they reach a certain level where they complete like Grade 10 or 11 and go back home, the knowledge they had at home and the one they got from school to the existing one, it can help learners to come with something that can</p>
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	<p>class with the real-life application outside it makes it learning more meaningful. Equally, in examination question like how sound is produced ? Then learners remember oh the other day we had the cultural group beating drum and then sound was produced. Culturally, IK should be</p>		<p>the local wine/drink called Kasipembe whereby you boil it because when talking about fractional you have to boil and every substance boil at its own boiling temperature.</p>			<p>sustain their life like farming (Agriculture).</p>
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<p>preservin g the cultural heritage of individual so that they do not forget them backgrou nd as they learn through their belief norm when elders tell those stories.</p> <p>Now learners can relate to what they have experienc ed physicall y to what they have been being asked. when they go out</p>					
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there is no science. Now, teacher can bring outside environm ent into the classroom or teacher take the learners to the outside environm ent and engage learners and the probabilit y of them remember ing is high because they have been involved in practical. Important ly, teachers should merge						
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	indigenous knowledge and Western science.						
Could you please tell me what the disadvantages of integrating local knowledge in Physics lessons are?	IK is not legitimate even if teachers attempt to integrate these knowledge into the science lessons from home the assessment is established on Western science. Almost 90 per cent of the end term tests are from modern science.	the curriculum seems to make us put Westernised science ahead of local knowledge. Cultural music instrument is never mentioned in any past examination paper	There is nothing much to do with disadvantages as I see it because it boosts learners' knowledge.	The teacher should always try to link classroom topic with real-life situations to build on their existing knowledge. It will also depend on teachers how they link it and transfer it to learners in a well-elaborated way either through stories	I can't think of more negative things about their local knowledge, but some learners misinterpret it and confuse it with the theory that they learn from school/classroom. Children may value one of them instead of trying to depend on what they know or balance both, they may choose to take what they learnt from school thinking or saying that what is learnt at home is different from the one learnt at	Integrating indigenous knowledge carries more advantages than negative impacts, the main challenge may be cultural background they perceive things in this regard may be different from others.	Learners may conclude that indigenous knowledge or what is learnt from home is wrong because the teacher taught it this way. However, this just requires the teacher to explain well and see how they can build learners' knowledge and not confuse it.

	<p>Learners doubted, why should they learn the IK if they are going to be assessed officially. Additionally, the curriculum is obliging teachers to put Western science above our local science. So, let us make IK legitimate to the curriculum.</p>				<p>school, so the one picked from school is more valuable and reliable than the one from home.</p>		
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